Dental Caries and Ear Infections in Preschool-Aged Children

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Purpose: The purpose of this case-control study was to assess the association between ear infection and dental caries.

Materials and Methods: The sample consisted of 126 children (range: two to five years) with no major medical problems or craniofacial anomalies. Ear infection history, demographic, dental, health and diet history of each child was determined using a questionnaire administered to the parent/guardian of the child. Dental charts were used to abstract dmft (decayed, missing and filled teeth) scores for children with dental caries (DC: dmft ≥ 1) and without caries (NDC: dmft = 0), and oral hygiene index (OHI) scores.

Results: Chi-square analysis indicated no differences in ear infection history between the 71 DC and 55 NDC (past year: 35% vs. 40%; lifetime: 30% vs. 31%) children. However, there was a trend (p = 0.07) for the mean number of ear infections to be higher in DC versus the NDC group. Baby bottle use was highest among those who had both ear infection and caries. Multivariate regression model revealed that OHI scores, reason for dental visit, and frequency of visits were the best predictors of dmft scores.

Conclusion: An association between dental caries and ear infection was not observed in this sample. Future investigations should explore common risk factors in increasing the risk of both diseases simultaneously.

Key words: dental caries, ear infection, children

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The 2000 National Institute of Dental and Craniofacial Research report (NIDCR, 2000) on the strategic plan to reduce racial and ethnic health disparities cites that there appears to be a relationship between dental caries and inner ear infections (acute otitis media; AOM) for which the exact biological mechanism is still not fully understood.

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The proposed relationship stems from studies performed in Finland (Uhari et al, 1996; Uhari et al, 1998) where investigators observed that xylitol chewing gum had a preventive effect by reducing the incidence of acute otitis media in pre-school age children. Several clinical trials conducted since 1975 have also shown that the consumption of xylitol is associated with a reduction in the incidence of dental caries (Sheinin and Makinen, 1975; Kandelman and Gagnon, 1990; Isokangas et al, 1988; Makinen et al 1995; Makinen et al, 1996; Beiswanger et al, 1998). Xylitol is a polyol sugar alcohol that has the same relative sweetness as sucrose, and has been used as a sugar substitute (Uhari et al, 1996). In vitro studies have found that xylitol inhibits the growth of *Streptococcus pneumoniae* responsible for AOM (Kantiokari et al, 1995) and *Streptococcus mutans* responsible for dental caries (Knuuttila and Makinen, 1975; Vadeboncoeur et al, 1983; Kantiokari et al, 1995).

The biological mechanisms for a direct association between caries and ear infections are not clear. In a study of the occurrence of negative middle ear pressure (initial stages of otitis media) in 6.5 to 7.5-year-old children, there was no relationship between caries and middle ear problems (Lildholdt et al, 1979). However, an indirect association between dental caries and ear infections is plausible through common risk factors of acquiring both infections. Previous studies have shown that bottle use, a risk factor for both diseases, increases the colonisation of *S. mutans* (Mohan et al, 1998; Lamas et al, 2003) and *S. pneumoniae* (Aniansson et al, 1994; Ford-Jones et al, 2002) in young children. To our knowledge, except for the study on negative middle ear pressure little else is known on whether children who have dental caries also have a higher likelihood of having a history of inner ear infections than children who do not have dental caries. The objectives of the present study were: 1. To compare the extent of ear infections among children with caries (DC) versus those without caries (NDC); 2. To assess the association between ear infections and dental caries after controlling for confounding risk factors such as demographic, dental history and behavior of parent and child, other health problems of child, and diet.

METHOD

Study design

A case-control design was utilised with dental caries as the outcome variable and ear infections as the exposure variable. Children with and without caries were identified from the new patient visits to the Pediatric Dental Center at one University Hospital (UH). All new patients between the ages of two to five years who were healthy and had no major medical problems or craniofacial anomalies were eligible for the study. Prior to seeking the parents' permission for participation in the study the medical information section of the dental chart was reviewed to make sure the child was eligible to participate in the study. An informed consent was signed by the parent/guardian of the child. The study was conducted from June 1st 2001 to August 31st 2002, and all eligible children identified during this time period with a signed consent participated in the study.

Data collection

Questionnaire data

The accompanying parents/guardians of these children were administered a simple questionnaire requesting answers to current and previous ear infection history and other risk factor information administered by trained investigators (NN, JW) blinded to the dental caries status of the child. The questions included were demographic (child's age and ethnicity, parent's age, education and occupation), child's height and weight, parent's smoking status, parent's dental history and dental insurance, child's dental history and behaviour (type and frequency of dental visits, frequency of brushing, use of fluoride supplements, sleeping with the bottle, daycare/school attendance, missed daycare/school days because of toothache, and use of chewing gum), child's medical history (frequency of physician diagnosed ear infections in the past year, type of medication prescribed for ear infection, use of tympanostomy tubes for ear infections, lifetime frequency of ear infections, frequency of coughs/colds during the past year, and history of asthma, allergy and enlarged adenoids), and child's diet. Specifically the diet questions included the child's frequency of consumption (each day or week) of sugar containing canned fruit, fruit drinks with sugar, dried fruits, soda pop, Koolaid, cake, cookies, doughnuts, pie, candy, chocolate bar, ice cream, milkshake and pudding. The cariogenic food frequency in terms of the total number of servings per week was computed for each child. The parents were able to give answers to all the questions since none responded with a 'don't know'.

Clinical information

Dental charts were used to abstract caries and oral hygiene index information of the child. Decayed, missing and filled teeth (dmft) scores of the primary dentition were computed for each child. Children with caries (DC) were defined as dmft ≥ 1 and those without caries (NDC) were defined as dmft = 0. An estimate of oral cleanliness was assessed using the debris index (DS-I) component of the simplified oral hygiene index (OHI-S) developed by Green and Vermillion (1964). This score was based on the tooth surface debris found in the buccal and lingual surfaces of two anterior teeth and four posterior teeth. Increasing scores indicate poorer oral hygiene of the child. The clinical examinations were completed by two calibrated pediatric residents

Table 1 Characteristics of the DC and NDC groups

Characteristics	DC group n = 71	NDC group n = 55	p-value
Demographics:			
Mean age of child	3.20 ± 1.0	3.11 ± 0.9	0.61
% African-American	75%	84%	0.58
Ear infection history:			
% with ear infection in past year	35%	40%	0.58
Mean no. of infections in past year	2.4 ± 2.2	1.5 ± 0.9	0.07
% with lifetime ear infections	30%	31%	0.87
Parental factors:			
Mean maternal age	28.0 ± 6.3	27.0 ± 6.5	0.28
% fathers with ≥ 12 years edn.	81%	83%	0.21
% with dental insurance	93%	83%	0.10
% with Medicaid	30%	40%	0.41
Child factors:			
% with first visit to dentist	55%	82%	0.01*
% with problematic reason for dental visits	30%	2%	0.00*
% with ≥ 2 times/day brushing	74%	60%	0.10
Mean oral hygiene index (OHI) Scores	9.9 ± 4.6	5.5 ± 2.9	0.00*
% bottle use as an infant	46%	18%	0.00*
% in day care or nursery school	58%	70%	0.15
% missing school because of tooth pain	22%	18%	0.66
Mean cariogenic servings per Week	40.9 ± 39.4	42.0 ± 33.3	0.87

* significant at $p < 0.05$

under the direct supervision of an experienced pediatric dentist (SC).

Statistical analysis

For the testing of the first objective, the frequency of ear infections among the DC and NDC group was tested using the chi-square test. The mean number of ear infections between the two groups was tested using the t-test. The differences between the DC and NDC groups in other characteristics were analyzed using either the chi-square or the t-test. Significance was assessed at $p < 0.05$.

For the testing of the second objective, the dmft scores (dependent) were used as a continuous variable for the linear regression analysis. The exposure variable was ear infection history and remained in the regression model at all times. The other independent variables (risk factors) were used as either a continuous or a categorical variable. Pearson's product moment and Spearman correlations were computed between the dmft scores and other risk factor variables. Covariates were considered for the final regression model if they were related to the dmft scores at $p < 0.10$. The final regression model consisted of both forced-entry and step-wise methods to predict dmft scores.

RESULTS

The sample consisted of 126 children (DC: 71, NDC: 55) whose parents/guardian responded to the questionnaire. Table 1 compares the various

Table 2 Correlation of risk factor variables with dmft scores

Characteristics	r value	p-value
Demographics:		
Age of child	0.11	0.22
Ethnicity	0.24	0.01*
Ear infection history:		
Ear infection in past year	0.02	0.83
No. of ear infection in past year	0.44	0.00*
Life time history	0.05	0.55
Parental factors:		
Maternal age	0.10	0.28
Father's education	–0.07	0.50
Dental insurance	0.10	0.27
Child factors:		
Frequency of dental visits	–0.38	0.00*
Reason for dental visit	0.37	0.00*
Frequency of brushing	0.16	0.08
Oral hygiene index (OHI) scores	0.69	0.00*
Bottle use as infant	0.31	0.00*
Day care/school attendance	–0.21	0.02*
Missing school due to tooth pain	0.22	0.01*
Cariogenic diet	–0.05	0.60

* Significant at $p < 0.05$

Table 3 Linear regression model for the prediction of dmft scores

Factors	beta ± standard error	p-value
Ethnicity	0.12 ± 0.33	0.72
Frequency of dental visits	–1.11 ± 0.50	0.02*
Reason for dental visit	2.54 ± 0.92	0.01*
Bottle use as infant	0.52 ± 0.76	0.49
Day care/school attendance	–0.72 ± 0.80	0.37
Ear infection in past year	0.14 ± 0.70	0.84
OHI scores	0.64 ± 0.08	0.00*
Intercept	0.12 ± 1.40	0.93

* Significant at $p < 0.05$

characteristics of the DC and NDC sample in terms of demographics, ear infection history, parental and child factors. The ages of the children ranged from two to five years, and the majority of the sample was African-American, with no differences in age or ethnicity between the DC and NDC groups.

A total of 25 children in the DC group had ear infections in the past year and 22 children in the NDC group, and this was not significantly different between the two groups. The lifetime prevalence of ear infection was also not different between the two groups. However, among those children who had ear infections in the past year there was a trend towards significance ($p = 0.07$) for the mean number of ear infections to be greater among the DC versus the NDC group (Table 1).

Parental factors such as maternal age, father's educational level, dental insurance and Medicaid participation did not differ between the two groups. A significantly greater proportion of DC group had a problematic reason for dental visit and bottle use as an infant. The DC group also had poorer oral hygiene as indicated by a significantly higher OHI scores. The NDC group had a significantly higher proportion of children who had visited the dentist for the first time. The other child factors did not differ between the two groups (Table 1).

As a first step in screening for the risk factor variables to be entered in the regression model, correlation analysis was computed to identify the variables that were related to the continuous dmft scores (Table 2). The variables that were chosen to be included for the regression model were ethnicity, number of ear infections in past year, frequency of dental visits, reason for dental visit, frequency of brushing, OHI scores, bottle use, day care/school attendance, and missing school due to tooth pain. From this list we eliminated number of ear infections in past year since this would have included only 47 children who had ear infections and comparison with those who did not have ear infections would not have been possible. Also frequency of brushing was eliminated since OHI scores were a more objective assessment of brushing behavior than the subjective reporting of this frequency from the parent/guardian. The model prediction did not improve with the inclusion of missing school due to tooth pain and thus was also eliminated.

The final linear regression model (Table 3) included dmft scores as the outcome variable and the independent variables were ear infection in the past year, ethnicity, frequency of dental visits, reasons for dental visit, bottle use, OHI scores, and day care/school attendance (Table 3). Approximately 58% of the variance in the dmft scores was explained by the seven independent variables in the model. The step-wise results indicated that higher OHI scores (r^2 = 49%), problematic reasons for dental visit (r^2 = 5%), and increased frequency of dental visits (r^2 = 4%) significantly predicted dmft scores.

DISCUSSION

The present study is the first to report on the association between dental caries and ear infections in preschool age children. The results of the study indicate that there does not seem to be an association between ear infection history in the past year/life time and dental caries. But, an interesting finding was that among children who had ear infections in the past year, there was a trend for the mean number of ear infections to be greater in the DC group versus the NDC group. To explore this finding, we further looked at a common risk factor (bottle use) for both dental caries and ear infections. In the sample of children who had ear infections, we found that 68% (17 out of 25) used the bottle as an infant in the DC group compared to only 18% (four out of 22) in the NDC group. Also, in this sample both dental caries and ear infections were independently associated with significantly greater bottle use. Bottle use significantly increases the colonization of *S. mutans* (Mohan et al, 1998; Lamas et al, 2003) and *S. pneumoniae* (Aniansson et al, 1994; Ford-Jones et al, 2002) in young children. Thus, we speculate that with the eustachian tube being blocked with bacteria and viruses because of upper respiratory tract infections, the vulnerability for young children to succumb to both infections could be increased. However, in the multivariate model predicting dmft scores, bottle use was not a significant predictor with the inclusion of other risk factors in the model. These results are consistent with a recent review (Reisine and Psoter, 2001) that suggests the evidence for the relationship between prolonged bottle use and dental caries is weak.

Approximately 50% of the variance in dmft scores was explained by oral hygiene index scores indicating that good oral hygiene practices could be very helpful in preventing decay in young children. Sound personal hygiene practices (brushing and flossing, regular dental visits) and adherence to a healthy lifestyle (low cariogenic diet) are the mainstays of personal approaches to oral health (US Dept. of Health and Human Services, 2000). The biofilm on tooth and root surfaces (dental plaque) can be disrupted to a large extent by the mechanical action of brushing and flossing (US Dept. of Health and Human Services, 2000).The results of this study are in agreement with previous investigations that employ clinical measures of plaque levels which show good oral hygiene to be associated with lower prevalence/incidence of caries (Reisine and Psoter, 2001).

In this study we also found that decreased dental visits were significantly associated with decreased dmft scores, indicating that parents may take their young children for a dental visit only when they perceive a problem. Interestingly, for the majority (66%) of the children in this sample this was their first dental visit, despite the fact that the majority of the parents/guardians had some form of dental insurance. Also, approximately 33% of the children had visited the dentist either once/twice a year, and this level of dental care utilization is much lower than the 43% reported for the U.S. population aged two years and older (Medical Expenditure Panel Survey, 1996). Previous reports have indicated that fewer younger children, non-white children, low-income children, and children of parents with low educational levels visit a dentist (Edelstein, 2002). The lower utilisation rate in our sample could be the reflection of predominantly younger and minority children.

The children in the DC group had significantly greater proportion of dental visits than the NDC group, but this was because a greater proportion (30%) of children in the DC group had a problematic reason for the dental visit. A total of 13% of the DC children had abscesses compared to none in the NDC group that could have contributed to the greater number of dental visits. It has been reported that minority children, children of parents with low educational attainment, and children living in poverty had more dental visits for dental pain than did their peers (Edelstein, 2002). Therefore, it was not surprising that problematic visits were significantly associated with higher dmft scores in this study. Education of parents/guardians regarding routine dental access for their children is essential in not only reducing tooth decay, but also tooth pain that accompanies it.

Ethnicity and daycare/school attendance that were significantly correlated to dmft scores were not significant predictors in the multivariate controlled model. Poverty and social class associated with minority status have indirect effect on caries risk by affecting behavior, use of preventive services, tooth brushing frequency, and sugar consumption. Further, the underlying basis for increased risks in minority groups could be associated with cultural norms concerning oral health, prenatal diet that could contribute to enamel hypoplasia, care of teeth, child rearing practices, and access to dental and medical care (Resine and Douglass, 1998). In this study, children who attended day care/school were found to have lower dmft scores which were contrary to the expectation of increased infections as a result of attending school. It is probable that children with recurrent infections stayed at home rather than attend school thus influencing the direction of the results.

The two possible prevention modalities that clinicians can adopt or counsel parents/guardians of young children would be to limit the use of the baby bottle, and the chewing of xylitol gum to reduce bacterial levels thereby preventing both dental caries and ear infections. Our results indicate that children who used the baby bottle had both infectious diseases prevalent. Parents/guardians should be advised against putting the baby to sleep with the bottle filled with milk, juice or other cariogenic liquids, and if they do then to fill the bottle with water. The anti-bacterial properties of xylitol chewing gum has been very effective in preventing both dental caries (Sheinin and Makinen, 1975; Kandelman and Gagnon, 1990; Isokangas et al, 1988; Makinen et al 1995; Makinen et al, 1996; Beiswanger et al, 1998), and ear infections (Uhari et al, 1996; Uhari et al, 1998). The ability of xylitol to reduce bacterial adherence in the human host has been known for some time (Jones, 2003), but poorly utilised in the United States. Recently, a pilot study (Autio and Courts, 2001) of xylitol chewing gum use in head start children (ages: 3 to 5 years) in Florida suggest that gum is well accepted by children. With increasing bacterial resistance to antibiotics, these two prevention methods can be an alternative but effective public health measure.

Several methodological limitations could have affected the results of this study. First, recall bias could have affected the results since the study relied on the subjective recall of ear infection history from the parents/guardians. Together with this question, we also asked if the ear infections were diagnosed by a physician and if medications were prescribed. Almost 98% of the ear infections were physician diagnosed and 96% of the children were prescribed medications, thus indicating some validity to this information. However, future studies should consider other designs where data on ear infections could be collected from the physicians as they are diagnosed. Second, the sample comprised of predominantly lower to lower middle class subjects seeking care in an urban dental center located in a hospital, and thus our results are applicable only to a similar group of individuals. Future studies are needed with a more representative and a larger sample size.

In conclusion, this study did not find an association between dental caries and inner ear infection. However, future studies should investigate the possible role of bottle use in increasing the risk of these two common childhood diseases.

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