Associations between dental treatment in the primary and permanent dentitions using insurance claims data

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Abstract

Purpose: The purpose of this study was to assess the associations between dental treatment in the early primary dentition and later treatment in the primary and permanent teeth.

Methods: Delta Dental Plan of Michigan insurance claims data on 9,886 children who were born in 1990 and were covered by dental insurance from 1990–1998 were used. Risk ratios (RR), screening test measures of sensitivity (SN) and specificity (SP), and evidence-based dentistry research measures of Likelihood Ratio (LR) and Number Needed to Treat (NTT) were calculated.

Results: Primary anterior tooth treatment at ages 0-3 was weakly associated (RR=1.43, 95% C.I.=1.23, 1.65) with treatment of the permanent first molars at ages 6-8 and had SN, SP, LR, and NNT values of 7.4, 95.3, 1.57, and 12 respectively. Primary posterior tooth treatment at ages 4-8 was more strongly associated with future permanent first molar treatment with a RR of 2.44 (95% C.I. = 2.26, 2.64) and SN, SP, LR, and NNT values of 65.9, 61.7, 1.72, and 6.

Conclusions: For this population, early childhood treatment in the primary anterior teeth was a weak predictor of future permanent first molar treatment. Primary posterior teeth treatment, while still not a strong predictor, was better than primary anterior teeth in predicting permanent tooth treatment. Caries treatment at ages 4-8 in the primary teeth was better than treatment at ages 0-3 in predicting permanent first molar treatment. (Pediatr Dent 22:469-474, 2000)

It has recently been recommended that the terms "early childhood caries" (ECC) and "severe early childhood caries" (S-ECC) be used to describe dental caries in infants and toddlers, with S-ECC referring specifically to children with atypical, progressive, acute, or rampant patterns of dental caries.[1-4] The associations between ECC or S-ECC and future caries development is of importance both to the researcher and to the clinician. For the researcher, this information could aid in the understanding of the etiological factors involved in the caries process. Do the factors that cause this condition persist into later life and lead to future caries in the primary and permanent dentitions, or is ECC a unique clinical entity that only affects the primary teeth in these children? For the clinician, this information could aid in caries risk assessment that is part of the decision making process in developing a preventive strategy for a patient.

Despite extensive previous research, there are still many questions regarding the risk factors for dental caries both in the primary and permanent dentitions. Previous carious experience, as well as various biological, psychosocial, and behavioral factors, have been shown to be associated with caries prevalence and incidence. Predictive multifactoral models, however, have only been able to explain a rather small percentage of variance in future caries experience with relatively low R^2 values.[5-8] Several studies have looked at the associations between ECC experience and future primary and permanent tooth caries.[9-17] The ability to predict future caries from a history of ECC was not clear-cut nor consistent, with the results varying with the populations studied, the definitions of caries, and the analytical methodology used.

This project utilizes longitudinal dental insurance claims data to investigate the associations between early childhood primary tooth treatment, later childhood primary tooth treatment, and permanent tooth treatment. The dataset is unique in its scale and its representation of treatment actually done in clinical practice.

Methods

This project used Delta Dental Plan of Michigan (DDPM) dental insurance claims data for treatment done in the state of Michigan. DDPM administers dental insurance programs for more than 2.6 million persons from a wide range of occupations and backgrounds in approximately 2,600 groups. Claims data from January 1, 1990 (the first full year of available data) to December 31, 1998 were used. The first inclusion criterion was that the children be born in 1990. We, therefore, had insurance claims data for this cohort of children from birth through age 8 years. This dataset contained 650,820 claims for 30,470 children who were born in 1990 and had at least one dental insurance claim from 1990 to 1998. The second inclusion criterion was that the families had continuous dental insurance coverage from 1990 to 1998. This limited the dataset to 284,716 unique claims for 9,886 children ages 0–8 over this 9 year period. These children were treated by 4,060 individual dentists in Michigan. Because the DDPM files con-

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Table 1. 2x2 Contingency Table and Calculations for Risk Ratios and Screening Measures

	No. of children with outcome	No. of children without outcome	Total
No. children with predictor factor	a	b	a+b
No. children without predictor factor	c	d	c+d
Total	a+c	b+d	a+b+c+d

Risk ratio = $\frac{\text{Risk of outcome in children with predictor factor}}{\text{Risk of outcome in children without predictor factor}} = \frac{a / (a+b)}{c / (c+d)}$

Sensitivity (SN)= Percentage of those with the outcome who had the predictor factor = 100 * a / (a+c)

Specificity (SP)= Percentage of those without the outcome who didn't have the predictor factor = 100 *d / (b+d)

Likelihood Ratio (LR) = $\frac{\text{Sensitivity}}{\text{100- Specificity}} = \frac{a / (a+c)}{100-(d / (b+d))}$

Number Needed to Treat (NNT) = $\frac{1}{(a / (a+b)) - (c / (c+d))}$

tain claims from most Michigan dentists, it was possible to track the dental treatment the children received even if they went to multiple dentists. Also, because we expect that almost all children who have continuous dental insurance coverage will have gone to a dentist by age 8 years. We assume that we have information on almost all children who had insurance coverage during this period. Therefore, this claims dataset should include essentially all dental treatment for this 1990 birth cohort from birth through age 8 years.

From the claims-based data file an individual child-based data file was constructed. For each child, the number of teeth with restorations or extractions in primary maxillary anterior teeth (central incisors, lateral incisors, and cuspids), primary posterior teeth (first and second molars), and all primary teeth at ages 0-3, 4-8, and 0-8 were calculated. The number of permanent first molars with restorations or extractions at ages 6-8 were tabulated. Restorations included amalgams, composite resins, and crowns; sealants were not included in these counts.

Dichotomous variables were constructed indicating whether or not the child had restorative or extraction treatment of primary maxillary anterior teeth, primary posterior teeth, any primary teeth, or a permanent first molar at the different age groups. Cutpoints of 1 or more treated teeth and 2 or more treated teeth were used to make the dichotomous variables that were used for the analyses.

In order to describe the associations between the different dichotomous predictor variables (primary anterior and posterior teeth at ages 0-3, 4-8, and 0-8) and the outcome of permanent first molar caries at ages 6-8, risk ratios were calculated along with their 95% confidence intervals. Because of possible bias caused by the use of dental sealants on the first permanent molars, stratified analyses were done and Cochran-Mantel-Haenszel adjusted risk ratios were calculated to detect confounding and to control for the use of sealants. In addition, Breslow-Day tests for homogeneity of the odds ratios were done to test for effect modification of the relationships by the use of sealants.

Two traditional screening measures, sensitivity (SN) and specificity (SP), were calculated. Calculations of positive and negative predictive value are not presented because these measures are highly sensitive to the prevalence of the outcome measure. In recent years, two clinically relevant measures, the likelihood ratio (LR) and number needed to treat (NTT) have been increasingly used in Evidence Based Medicine and Evidence Based Dentistry (EBD) research and are included in these analyses.[18] The set-up of the 2x2 contingency tables along with the calculations for the risk ratios, screening, and EBD measures are shown in Table 1. The Statistical Analysis System for Windows (SAS), version 6.12 software, was used for all data management and statistical analyses.[19]

Table 2. Mean Number of Treated Teeth and Proportion of Children with Treated Teeth by Teeth and Age Groups (N=9886)

Tooth Group	Age Group	Mean no. of treated teeth (SE)	Mean no. of treated teeth in those with treated teeth (SE)	% of children with 1 or more treated teeth (N)	% of children with 2 or more treated teeth (N)
Primary Anterior	0-3	0.1 (0.01)	2.5 (0.06)	5 (524)	3 (332)
Primary Anterior	4-8	0.3 (0.01)	1.9 (0.03)	15 (1493)	8 (814)
Primary Anterior	0-8	0.4 (0.01)	2.2 (0.03)	18 (1739)	10 (1028)
Primary Posterior	0-3	0.2 (0.01)	2.7 (0.07)	8 (761)	5 (500)
Primary Posterior	4-8	1.5 (0.02)	3.5 (0.03)	44 (4365)	33 (3297)
Primary Posterior	0-8	1.6 (0.02)	3.6 (0.03)	45 (4472)	35 (3433)
All Primary	0-3	0.4 (0.01)	3.4 (0.09)	11 (1042)	7 (701)
All Primary	4-8	2.1 (0.03)	3.9 (0.04)	53 (5202)	4 (4015)
All Primary	0-8	2.3 (0.03)	4.2 (0.04)	54 (5351)	43 (4202)
Permanent Molars	6-8	0.4 (0.01)	2.1 (0.02)	21 (2111)	13 (1302)

SE = Standard error

Table 3. Risk Ratios and Screening Measures for Predictor Tooth Groups and Outcome of Treatment of a First Permanent Molar, Cutpoint = 1 Treated Tooth or Greater (N=9886 Children)

Predictor tooth group	Predictor age group	Risk Ratio (RR) (95% C.I.)	Sensitivity (SN)	Specificity (SP)	Likelihood Ratio (LR)	Number Needed to Treat (NNT)
Primary Anterior	0-3	1.43 (1.23, 1.65)	7.4	95.3	1.57	12
Primary Anterior	4-8	1.37 (1.25, 1.51)	19.6	86.1	1.41	14
Primary Anterior	0-8	1.39 (1.27, 1.52)	22.9	83.9	1.42	13
Primary Posterior	0-3	1.84 (1.65, 2.05)	13.3	93.8	2.15	6
Primary Posterior	4-8	2.44 (2.26,2.64)	65.9	61.7	1.72	6
Primary Posterior	0-8	2.46 (2.27,2.66)	67.0	60.7	1.70	6
All Primary	0-3	1.63 (1.48, 1.81)	16.2	90.9	1.78	8
All Primary	4-8	2.35 (2.16, 2.55)	72.3	52.7	1.53	6
All Primary	0-8	2.33 (2.14, 2.53)	73.3	51.1	1.50	7

Results

Mean number of treated teeth and proportion of children receiving treatment

In children 3 years of age or younger, the mean number of treated primary anterior teeth was 0.1 teeth (Table 2). For children in this age group who had treatment, the mean number of treated primary anterior teeth was 2.5 teeth. Thus, it appears that dental caries in these young children usually affects several teeth. The proportion of children having at least one primary anterior tooth treated between ages 0 and 3 was 5% (524 children), and 3% of the children had treatment on at least two primary anterior teeth (Table 2). For all primary teeth in children age 3 years and younger, 7% of the children had at least one treatment claim filed and the mean number of treated teeth for those with treatment was 3.4 teeth.

For all primary teeth in the children from ages 0 to 8, the mean number of treated teeth was 2.3, with 54% of the children receiving treatment on at least one primary tooth and 43% of the children having two or more primary teeth treated. For children who received treatment, an average of 4.2 teeth were treated. Again, most treatment of primary teeth involved several teeth. Permanent tooth treatment was evaluated in children from the ages of 6 to 8. For this group, 21% of the children had a permanent first molar treated with the mean number of treated teeth being 0.4. Those who did have treatment, however, had an average of 2.0 permanent first molars treated and 13% of the children had two or more permanent first molars restored.

Prediction of future permanent first molar treatment from primary anterior teeth treatment

Using a cutpoint of 1 or more treated teeth for creating the dichotomous variables, children 0-3 years old with any treatment in the primary anterior teeth had 1.43 times the risk (95% C.I.=1.23, 1.65) for having some treatment in the first permanent molars compared to children who didn't have any primary anterior tooth treatment (Table 3). In order to determine the influence of sealants on this association, stratified analyses by sealant use was conducted. For children who had no sealants, the Risk Ratio (RR) was 1.32 (95% C.I.=1.09, 1.60); for those with sealants the RR was 1.55 (95% C.I.=1.25, 1.91). The Mantel-Haenszel-adjusted RR was 1.41 (95% C.I.=1.22, 1.63), which is very similar to the crude value, indicating little confounding of the association by the use of sealants. The Breslow-Day Test for Homogeneity had a p value of 0.177, indicating that there was no significant difference between the stratified odds ratio, and, therefore, no evidence of effect modification of the association by the use of sealants. Sensitivity (SN) was 7.4%, indicating that 7.4% of the children who had any first permanent molar treatment at ages 6-8 years also had some primary anterior tooth treatment at ages 0-3 years. The specificity (SP) of 95.3% indicates that 95.3% of the children who didn't have any permanent first molar treatment also didn't have any primary anterior treatment. Generally in this study, SP was much higher than the SN, indicating that prediction of the *lack* of future treatment was better than the prediction of the occurrence of future treatment.

The Likelihood Ratio (LR) incorporates both the SN and SP measures and is less affected by the prevalence of the outcome measure (permanent first molar treatment) than SN and SP and the two other commonly used screening measures of positive and negative predictive value.[18] The LR of 1.57 (Table 3) is the likelihood of a child with permanent first molar treatment having had primary anterior treatment compared to the likelihood of a child without permanent first molar treatment having had primary anterior tooth treatment. In practical terms, the larger the LR, the better the screening test. This rather low LR is indicative of the relatively low screening values.

The Number Needed to Treat (NNT) measure is usually used to indicate the number of patients a practitioner would need to treat in order to prevent one additional bad outcome. In the present comparison of primary anterior teeth and first permanent molar treatment, the NNT indicates the number of children with anterior treatment a practitioner would need to see in order to expect to detect one child with future posterior treatment needs. In this context, the measure could be considered the "number needed to detect". In practical terms, a smaller NNT value indicates a more efficient screening test. Our results of a NNT of 12 (NNT is always rounded up to the nearest whole number) indicates that a practitioner would be expected to need to see 12 patients with primary anterior treatment at ages 0-3 years in order to detect one child who would eventually require restoration of a first permanent molar in the future at ages 6-8 years.

Risk Ratio (RR) and screening measures using a cutpoint of two or more primary anterior treated teeth and two or more treated permanent first molars were also calculated, but are not shown on the table. Using this higher cutpoint, the RR was 1.44 (95% C.I. = 1.22,1.69) and the SN, SP, LR, and NNT were, respectively, 5.7, 96.4, 1.59, and 11. These results do not greatly differ from that using the cutpoint of one or more treated teeth. Other cutpoints were also evaluated, and did not produce greatly differing values. The high similarities of the results using either one or two teeth as cutpoints is because the children with treatment were likely to have multiple teeth treated, as discussed earlier. Because the cutpoints had little effect on the results, only the results using the cutpoints of one or more treated teeth are presented in this paper.

Prediction of future permanent first molar treatment from primary posterior teeth treatment

Higher RR, SN, and LR values, as well as lower NNT values were seen for primary posterior teeth treated in any of the age groups compared to primary anterior teeth (Table 3). Children with any treatment in the primary posterior teeth from ages 0-8 years had 2.46 times the risk (95% C.I. = 2.27, 2.66) of having treatment in their permanent first molars than children who didn't have primary posterior tooth treatment. The SNs for the primary posterior teeth treatment at ages 4-8 and 0-8 years were moderately strong (65.9 and 67.0% respectively), as were the SNs for treatment of all primary teeth at ages 4-8 and 0-8 years (72.3 and 73.3% respectively). While still not a strong predictor, it is evident that treatment of the primary posterior teeth, particularly at ages 4-8 years, was a better predictor of permanent first molar treatment than treatment in the primary anterior teeth. Stratified analyses by sealant use were also conducted and, as discussed previously with the primary anterior teeth, no evidence of confounding or effect modification by sealants was detected. For the primary posterior teeth, unlike the primary anterior teeth, the risk ratios for the children who didn't have sealants were all higher than for those with sealants.

Discussion

The use of dental insurance claims data provides the opportunity to see treatment patterns as they exist in actual clinic practice. Although these children are probably typical of persons who have long-term private dental insurance coverage, the children in this study are not likely representative of all children in Michigan. Nationwide, about 40% of the population is covered by private dental insurance.[21] We would expect the people in our study who have private dental insurance to have higher than average socioeconomic status, which is usually associated with better oral health conditions. These results are therefore not necessarily generalizable to children who do not have private dental insurance and may have very different socioeconomic and other demographic characteristics.

Epidemiological surveys and randomized clinical trials typically use trained and standardized examiners who use rigorous detailed criteria in their dental examinations. The data in this project represent the personal diagnostic and treatment decisions of literally thousands of clinicians. While it is impossible to assess the validity and consistency of each examiner, taken as a whole we would expect individual practitioner variability and inconsistency to balance out. Certain biases are also present in a study such as this. The practitioners are not blinded to the previous caries or treatment status of the patient. The dentist may see, remember, or see records of previous treatment that could bias their treatment of other teeth. This bias would tend to make the observed associations and screening values higher than they would be otherwise. Similarly, dentists' treatment patterns, where some dentists are more aggressive or more conservative in their treatment, would tend to make the observed associations and screening values higher than they would be otherwise.

Another bias is that these were children with good access to, and high use of, dental services. It is quite likely that the dentists treating the young children with dental problems provided an array of preventive services (e.g., sealants, oral hygiene instruction, fluoride therapies, dietary counseling), that may have helped to prevent these children from developing future caries. This bias would tend to diminish the observed associations and screening values. We investigated the role of sealants by stratifying the data by whether or not the children had any sealants placed. For the children who didn't have sealants, they had slightly stronger associations between the primary posterior teeth treatment and permanent first molar treatment than those children with sealants. However, confounding and effect modification by sealant use was not found to be statistically significant, and therefore we presented only the crude associations.

While there are certain limitations of generalizability and bias present in this study, the strengths of the study lies in its large number of patients, its eight year duration, and in its use of actual clinical practice data. Traditional prospective longitudinal cohort studies are the ideal way to determine cause and effect associations such as in caries risk research. These studies, however, are very difficult and expensive to conduct because of the problems of long-term follow-up of patients. While not a substitute for longitudinal studies, use of insurance claims data is a relatively simple, inexpensive, and efficient way to conduct such research. These data are likely to represent well treatment patterns typically seen in dental offices.

The percentage of children age 3 years or younger in this study that had any dental treatment ranged from 3.4% using the criterion of children with two or more treated anterior teeth, to 10.5% using a more lenient criterion of children with one or more treated primary teeth (Table 2). These figures are for the percentage of children who have received dental treatment; there may have been some children who had carious teeth who did not receive treatment. Since these are children with dental insurance, however, we would expect that most affected children would have had treatment. While some studies of high risk groups such as Native Americans have found very high caries rates in young children (often over 50%)[22, 23], other studies in general populations have found ECC prevalences in young children to be under 10%.[24, 25] Ripa estimated the prevalence of nursing caries in the U.S. to be no higher than 5%,[26] although he gives no specific details for his case definition of "nursing caries" for this estimate.

Several studies have observed statistically significant associations between primary caries experience and future primary or permanent tooth caries.[12, 13, 15-17, 27] The Al-Shalan et al.[17] research was conducted at a university pediatric dental clinic where the prevalence of ECC was 50% in children less than age 4 years, and 40% of the children (average age 9 years at last examination) had caries or treatment of a first molar by the end of the study period. They found an odds ratio of 3.39 for ECC and caries in permanent molars. While not published, the SN and SP values were 70 and 56% respectively and a LR of 1.7 and NNT of 4 .

Several studies, while observing associations between early primary tooth and future caries, have noted the limitations of predicting future caries from early primary tooth experience.[9, 10, 14, 28, 29] Adler[28] found significant correlation coefficients between caries experience of the primary molars and permanent teeth four years later, but concluded: "...no individual prognosis as to future caries prevalence in the permanent dentition can be made based on the caries prevalence in the primary molars of lower grade school children." Kaste et al.[14] found that Head Start children with an overall dmft of 5 or more teeth had a RR of 2.4 (95% C.I.=1.4, 4.3) for a DMFT of 5 or more teeth 10 years later, but found lower RRs when only primary anterior teeth were the predictor teeth. Caries on the buccal or lingual surfaces of a primary maxillary incisor had an insignificant RR of 1.1 (95% C.I.=0.6, 1.5) for high DMFT, and classifications of 2 or more or 3 or more carious anterior primary teeth had RRs of 1.6 (95% C.I.=1.1, 2.4) and 1.4 (95% C.I.=1.0, 1.9), respectively. The authors concluded that an overall dmft of 5 or more teeth in the primary teeth appeared to be a risk factor for caries in the later permanent teeth, but buccal/lingual maxillary incisor caries (commonly indicative of "nursing caries") was not a strong indicator for future permanent caries.

The current study also found fairly low associations of early tooth treatment and later permanent molar treatment, as well as low values of sensitivity and positive predictive value. Primary posterior teeth, particularly in the older age group, appeared to have more predictive utility as indicated by the higher RRs and screening test values (Table 3).

Clinically, it makes sense that the stronger associations and predictive ability would be seen with the later primary posterior teeth. We would expect that the various causative factors leading to treatment at ages 6-8 would be more similar to conditions at ages 4-8 than at ages 0-3. We would also expect that, because of their similar morphologies, molar teeth in the permanent dentition would show more treatment similarities to primary molar treatment than primary anterior teeth.

ECC and S-ECC are characterized by some unique and specific characteristics, such as high dietary sugar intake and particular nursing habits. It is reasonable that once these "temporal" factors are removed, such as by the cessation of a particular nursing habit, that a child's risk for other caries would diminish. However, it is also clear from these results that children with treatment in the primary teeth were, in fact, more likely to have future permanent tooth treatment. Various behavioral, psychosocial, nutritional (particularly fluoride), dietary, morphological, bacteriological, and immunological factors in early childhood could persist into later school years to influence future caries activity. Clinicians can help patients to modify those factors that can be changed, and at least be aware of those factors that cannot be altered, in to order prevent future caries.

We are not yet able to accurately predict future caries activity in individuals using any simple clinical bacteriological tests[30, 31] or with even complex statistical models[5-8] that consider a multitude of risk factors. This research found rather weak associations between treatment in the early primary teeth and later treatment in the permanent molars. In determining future caries risk, clinicians should still consider past primary tooth caries activity, but this must be done with consideration of the limitations demonstrated in this and other studies. It is hoped that clinicians will have better predictive tools for assessing caries risk in the future.

Conclusions

1. Early childhood caries treatment in the primary anterior teeth was not strongly associated with treatment of the permanent first molars.
2. Primary posterior teeth treatment was better than primary anterior teeth treatment in predicting permanent tooth treatment.
3. Caries treatment at ages 4-8 in the primary teeth was better than treatment at ages 0-3 in predicting permanent tooth treatment.
4. It is easier to predict those children who are not likely to develop caries than those who will.

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