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Time until first dental caries for young children first seen in Federally Qualified Health Centers: a retrospective cohort study

RA Kuthy, M Jones, G Kavand, E Momany, N Askelson, D Chi, G Wehby, and P Damiano

Abstract

Objective—The study assessed the time until first dental caries for young children seen at 5 Federally Qualified Health Centers (FQHC) in Iowa and the relationship with the frequency and gaps (in months) of dental episodes, the number of topical fluoride treatments, and the number of dentists caring for the subject.

Methods—Forty children were randomly selected at each FQHC (n=200). All children were continuously enrolled in the Medicaid program and had their first dental visit prior to age 6. Dental chart findings, claims data for the child and family, and birth certificate information were merged into one dataset. Dental visits were followed for a minimum of 36 months, including dental visits external to the FQHCs. Using time until first caries as the dependent variable, the data were subject to left, interval, and right censoring and were analyzed via Weibull regression.

Results—Slightly more than half of the 200 children experienced caries. Regression analysis indicated that the hazard rate of first dental caries increased by approximately 2% with each additional month that transpired between preventive recall examinations. In addition, children with older siblings who had a dental visit at the same center during the previous year prior to the subject's first visit were more likely to have a longer time until first dental caries.

Conclusions—Timing of dental care episodes was associated with caries experience in young children from low income families. Dental professionals should focus on regularity of dental care in order to prevent or delay caries experience in young children.

Introduction

Dental caries remains the most prevalent chronic disease among U.S. children (1), with its impact especially affecting children from lower socio-economic families (2–5). The literature is replete with articles concerning caries risk factors (6–9) and the use of caries prediction models to target individuals (10). Similarly, researchers have explored caries associations with the child's birthweight (11, 12), mode of birth delivery (13, 14), Apgar score (15), parental tobacco use (16, 17), soft drink consumption and dietary patterns (18, 19), child's weight gain (20, 21), and the family's geographic location and perception of dental fatalism (22). Family structure and the mother's use of dental services also appear to have an impact on the child's caries experience (23, 24).

Concern about caries experience among children, especially at the preschool years, has been a catalyst for devoting one of the U.S. oral health objectives to “reduce the proportion of young children aged 3 to 5 years with dental caries experience in their primary teeth” (25). Although there is a sharp increase in annual dental utilization by the time of school entry

(26), the percent of children who see a dentist before age 3 is extremely low, especially among more indigent families even though professional guidelines recommend children receive their first dental visit by age one (27–29). The intent is to provide a ‘dental home’ where the child can be clinically examined for dental caries manifestations, a caries risk analysis can be performed, and providers can impart anticipatory guidance about oral growth and development and measures to protect the dentition (30). The importance of an early first dental visit, coupled with ongoing dental care, could have a profound effect on preventing disease and reducing cost, both at the individual and societal level (31, 32).

The National Network for Oral Health Access (NNOHA) represents a network of dental providers at federally qualified health centers (FQHC) who care for more than 4 million underserved individuals nationally (33). NNOHA has recommended the year one oral health examination (34). FQHCs are a key part of the oral health care “safety net”, delivering “...a significant level of health care and other health-related services to uninsured, Medicaid, and other vulnerable patients” (35). The Medicaid program in the United States, which was established as an amendment to the Social Security Act of 1965, is a “health and long-term care coverage program that is jointly financed by states and the federal government” to address the needs of lower income families. Each state has established and administered its own program by determining the type, amount, duration, and scope of services covered using broad federal guidelines. However, states must cover several mandatory benefits, including dental care for children. The purpose of this study was to investigate the factors related to the time until a Medicaid-enrolled child who initially received their care at an FQHC had their first dental caries experienced (diagnosed or treated). We hypothesized that children will be caries free for a longer period of time if they (1) had more episodes of dental care, (2) had shorter time gaps between dental episodes, (3) had a higher frequency of receiving topical fluoride treatments, and (4) remained with the same dentist throughout the study.

Subjects and Methods

Inclusion criteria

Iowa children were eligible for inclusion in the sampling frame if they met the following criteria: (1) Medicaid-enrolled within two months of birth; (2) continuously Medicaid-enrolled (i.e., no greater than 2 month eligibility gaps) throughout the study period; (3) less than 6 years old as of calendar year 2006; (4) had their initial comprehensive dental visit (ADA Current Dental Terminology [CDT] claims code D0145 or D0150) at one of Iowa’s FQHCs between 2002 and 2006; and (5) had no previous comprehensive dental Medicaid claims submitted from other dental providers in the state. Only 5 federally qualified health centers (FQHCs) had sufficient numbers of eligible children during this time frame who met all of the aforementioned criteria.

Sampling

For this retrospective cohort study a randomized list of 60 children was generated for each of the 5 centers and then provided to FQHC staff for chart retrieval. Oversampling was performed to account for either incorrect Medicaid eligibility or claims data entry or

difficulty in retrieving the chart, which in some cases required staff to collect charts from off-site archival sites. The first 40 charts from each FQHC whose first dental examination coincided with the submitted Medicaid claims data were included in the analysis. The University of Iowa Institutional Review Board granted human subjects approval for this project.

Data collection

Data for the selected subjects were collected from four sources. First, the investigators reviewed the dental charts, both paper and electronic forms (after calendar year 2006), at each FQHC, and abstracted the following information: date of birth; sex; race/ethnicity; whether a translator was required; date of initial examination; whether there was a dental treatment plan; whether topical fluoride therapy was provided, along with date rendered; whether the patient had restorations and/or extractions in the treatment plan; date of last dental visit in that episode; whether the patient was placed on a dental preventive recall system; and any written narrative. The diagnosis of dental caries was made by the clinical dentist who was providing care to this child and then it was either recorded in the paper or electronic health record as part of the patient's treatment plan. These dentists were not calibrated for caries detection. Race was classified by parental assessment as part of the patient enrollment procedures used by the centers. The chart review process was repeated for each subsequent episode, with date of the periodic oral examination serving as the commencement date for the next episode. Thus, a new episode of dental care at the FQHC was defined from the provider's perspective (36). That is, an episode began with an oral examination and/or treatment plan for the child and then ended on the date when either the child's treatment plan was completed or the last date of services followed by a substantial time (greater than 3 months) gap that indicated discontinuation of treatment. In the absence of disease, the start and end dates of an episode were identical; otherwise, the length of the episode was based on the time from first to last visit to correct all diagnosed caries. Whether the patient was seen by the same provider as the previous episode was also recorded for each subsequent dental episode. Episodes were documented through calendar year 2009 with one exception. If a dental episode was started near the end of calendar year 2009 and continued into 2010, then dental service data from that episode was included.

Second, after their initial comprehensive visit at a FQHC children may have received dental services from other Medicaid providers who were not affiliated with the FQHC. In some instances, children were referred by a FQHC dentist for specialty services (e.g., pediatric dentistry) outside of the FQHC system. Alternatively, parents may have just decided to seek dental care for the child elsewhere, sometimes permanently while other times intermittently. Such non-FQHC services were used to create new dental episodes external to the FQHC. However, since the non-FQHC claims data were only for billed services, no treatment plans existed. Thus, separate operative rules were needed to describe an episode; a new non-FQHC dental episode occurred when there was a six-month or longer gap between two consecutive visits. If there was a one- to five- month gap between dental visits, however, a new episode was started only when there was either a comprehensive (CDT 0150) or periodic oral examination billing code (CDT 0120) from a new dental care provider. When there was a referral from a FQHC to a non-FQHC provider, and the referral visit at non-

FQHC occurred within three months following the FQHC visit, the FQHC and non-FQHC visits were considered as one single episode because the referring dentist had noted the dental disease.

Third, for family members who were also Medicaid-enrolled, information about whether a parent or siblings sought dental care within the prior year to the child's first dental visit were added to the master file for each child. Moreover, medical claims were reviewed for each child to collect whether the child received well-child visits (WCV) at intervals prescribed by American Academy of Pediatrics (37). WCVs are regularly scheduled visits to a medical provider during the first two (or more) years of life "due to the rapid growth and change that occurs during infancy.". During each visit, the medical provider monitors, advises, and answers questions about the infant's growth and development. Similarly, information was added from medical claims to assess if parents and other siblings sought any preventive (i.e., well-child/adult) medical care during the previous year prior to the first dental visit.

Lastly, the child's birth certificate was the source for the mother's age and educational level at the child's birth, birth order of this child, Apgar score, number of prenatal visits, and tobacco use during pregnancy. We were able to match the data from the birth certificates of 187 of the 200 subjects.

Variables

The primary outcome variable was time until first dental caries experience, which was defined as the date at which the caries was first noted in the chart at the FQHC or the date when the Medicaid dental claims data indicated a restoration or extraction code (for the non-FQHC episodes). The main predictor variables were number of episodes of dental care, number of topical fluoride treatments, and changes in dental care providers before first dental caries. These three predictor variables were time-dependent (i.e., they changed from birth to the end of follow-up). Duration of gaps (months) between episodes of dental care was also included as another variable. In addition, several fixed (non-time-dependent) covariates, including demographic characteristics of child and mother, pregnancy characteristics, and medical and dental visits of other family members prior to the subject's first dental visit were included in the analyses.

Statistical analysis

Dental claims data were followed for a minimum of 36 months after the first dental episode. The available data for the time until first dental caries were placed in one of three categories: left-censored - if dental caries was diagnosed at the first dental visit, indicating that the caries existed prior to the child's first dental visit; interval-censored - if dental caries was diagnosed during the study period, but the caries appeared sometime between episodes; and right-censored - if dental caries was not diagnosed or treated at any time throughout the study. The LIFEREG procedure was used to build the Weibull parametric model for the time until first dental caries. The model consisted of only fixed covariates since time-dependent variables cannot be used in the LIFEREG procedure (38). The backward elimination technique was then used to select the most relevant fixed covariates for this regression model. Finally, time-dependent variables, along with the selected fixed covariates, were

included to fit a Weibull parametric survival model for the time until first dental caries, using PARM_ICE software, version 3.0 (39). Unfortunately, the only available software for interval-censored data and time-dependent covariates allows for inclusion of only one fixed and one time-dependent variable in the analysis. Therefore, a separate model is presented for each of four tested time-dependent variables (dental episodes; fluoride therapies; length of time between dental episodes; and changes in dental provider). SAS version 9.3 was used for all other statistical analyses, with statistical significance set at $p < 0.05$.

Results

The age distribution at first visit ranged from 4 to 62 months; mean age was 25.6 months (s.d., 12.9); and median was 23 months. Of the 200 children who started receiving dental care at FQHCs, 77% returned to the FQHC, whereas 13% received their second episode of dental care outside the FQHC. There was only one dental episode for the remaining 20 children. Overall, 34% sought dental care at one or more dental providers external to the FQHC throughout the study period. Nine percent of the 200 children were referred for specialty care at an external location sometime during the study period, while the other children sought care elsewhere for an undetermined reason.

Age, in months, at first dental caries experience for the 101 children with dental caries and age at last dental episode for the remaining 99 children without dental caries is displayed in Figure 1. For the non-carries group, this age reflects the last time that the child was seen by a dentist during the data collection period. Twenty-one children had some dental caries at their first dental visit (mean age: 40.1 months (s.d., 11.4) [left-censored]). An additional 80 children developed caries sometime during the study period (interval-censored), whereas 99 children did not have a record of any caries experience (right-censored). Table 1 displays the number of chair-side fluoride therapies, changes in dental care providers, and dental care episodes for those with and without any dental caries experience.

Table 2 displays the results of univariable, Weibull regression analyses predicting the hazard ratio of the first dental caries based on the fixed covariates. Among the covariates, only the number of dental visits of other Medicaid-enrolled children in the household provided at the FQHCs during the year prior to the subject's first dental visit was significantly related to the hazard ratio of the first dental caries. For convenience, we have displayed the dichotomous version (0 versus 1 or more) in the Table. However, the linear version, which is the version used in Table 3, showed almost identical results (HR = 1.226 [1.003, 1.499], $p = 0.047$). Thus, with one unit increase in the number of dental visits of other children during a 12-month period prior to the subject's first dental visit, the hazard of first dental caries is expected to increase by approximately 23% (i.e., 1.226).

The multivariable Weibull survival models, having both fixed and time-dependent variables in the models, are summarized in Table 3. Duration of gaps between episodes of dental care, in months, was the only time-dependent variable in the model which was significantly associated with the hazard ratio of first dental caries ($p = 0.006$). Thus, with one unit increase in the length of gaps (months) between dental care episodes the hazard of first dental caries was expected to increase by about 2% (HR = 1.023). In addition, the association between the

number of topical fluoride therapies before the first dental caries and the hazard ratio of first dental caries was near statistical significance ($p=0.094$), indicating with one unit increase in the number of topical fluoride therapies, the hazard of first dental caries decreased by about 14% ($HR = 0.861$).

Discussion

There has been a resurgence of interest about caries development in the pre-school years (40), especially from a preventive perspective. Unfortunately, there have been few longitudinal caries studies with preschool children (6, 41), especially in the United States (8, 22); however, children who develop early caries show high caries progression and they are at higher risk for new carious lesions (42). Likewise, there appears to be a relationship between caries experience in the primary and permanent dentitions (43, 44), which further reinforces the need for early preventive and educational visits among preschool children.

Only one of the original four hypothesized associations concerning longer time until first caries was statistically significant. Children who had shorter gaps between dental episodes were more likely to be caries free, when taking into consideration the number of dental visits by other Medicaid-enrolled children in the household. Quite possibly, these families were more responsive to having regular periodic examinations than others, especially when this was performed in conjunction with other children in the household. The major drawback to scheduling the entire household at one time, however, is that a broken appointment by a family creates a substantial lost opportunity cost on the center.

Conversely, the null hypothesis was not rejected for the number of dental episodes, the frequency of topical fluoride treatments and remaining with the same clinical dentist throughout the study, when adjusting for the number of dental visits at the FQHC by other children in the household during the 12-months prior to the subject's first dental visit. Although one would suspect that there is some correlation between number of dental episodes and shorter periods between gaps, perhaps the differentiation becomes much more noticeable only for those with irregular gaps (months) between recall visits.

The finding that the number of topical fluoride treatment was negatively associated with the hazard ratio of dental caries was not surprising given the caries preventive effect of fluoride. While there were no notations in the charts (for those who were seen at the FQHCs) about why fluoride treatments were performed prior to the first dental caries, it is presumed that dentists did this procedure because the subject was perceived to be at higher risk. Although the hazard ratio was the largest of the time dependent variables studied, the association was not statistically significant; thus, future investigations with higher statistical power are warranted.

The finding that a change in dental providers was not statistically significant was somewhat unexpected. Less than half of the subjects stayed with the same dentist throughout the study period. Prior studies have shown that switching dentists leads to a higher replacement of dental restorations than staying with the same provider (45–47). One would suspect that a similar result would occur when diagnosing dental caries, especially in FQHCs in the United

States and elsewhere, where there are dentist retention concerns (48, 49). The restorative replacement studies, however, occurred with a substantially older age cohort. With a young population, there may be some hesitancy by the new provider, especially by a general dentist, to perform any definitive restorative care, especially at the initial patient-provider appointment. Even though there has been an emphasis on earlier dental visits for young children in the United States during the past decade, the dentists' wherewithal to comply with newer guidance may not be associated with the capabilities to behaviorally manage younger children. Future research should explore whether there are differences between the age at first dental caries between private and public sector dentists who treat Medicaid-enrolled children. If there are differences, then a concerted effort should be initiated to provide continuing education opportunities for dentists regarding the care for very young children.

The reason that the number of dental visits was included in the bivariate, and thus multivariable model, was the expectation that several family members had batch appointments (i.e., members would have dental recall visits as a group). Possibly, the other children in the household had a higher prevalence of dental caries as expressed by the increased number of dental visits during the previous year. This subject also had an increased risk of dental caries; thus, their first dental caries was diagnosed/treated at an earlier age compared to other subjects whose siblings had lower number of dental visits. A possible explanation for why there is a relationship between the number of children in a household and a lower frequency of children with first dental caries in this population is that once one child from a family enters the dental delivery system, then younger siblings are brought along to seek dental care (50). Other studies that have studied sibship size and birth order for diseases have hypothesized that younger children in a family may be more prone to earlier disease because of its infectious etiology (51). Although the current study has household data, we are not able to validate whether the children have the same parents or are from blended families. Further research is warranted about looking at the family unit (i.e., all children in the household versus only those who are sibships) for frequent and regular dental care, especially during the preschool years. Moreover, a word of caution must be given for interpreting the number of well-child visits at the FQHC prior to the first dental visit. Although 182 of the 200 children had at least one well-child visit prior to the first dental visit, only 55 of the children had one or more of these medical visits at the same health facility as the dental visit even though there were medical providers at each of these centers. One possible explanation for this apparent paradox is that parents had more difficulty finding a dentist willing to see a young Medicaid-enrolled child than they did for a physician to provide the well-child care.

Unlike other studies that found statistically significant results for caries in the primary dentition and racial groups (52), level of mother's education (41, 53), and smoking (54), this study did not. Additionally, we did not find a significant difference in the hazard ratio of dental caries between children delivered vaginally versus those by caesarean. Several investigations have shown that the mode of birth delivery was associated with time and composition of infants' oral microflora (13, 55, 56); however, another cohort study failed to find significant relationship between the prevalence of caries in young children and delivery mode (14). Similarly, this study did not find a statistically significant relationship between age at first dental visit and time until first dental caries.

The investigators considered not including the left-censored data because the dentists had neither direct input into educational efforts to prevent oral disease nor did they intercede with any preventive treatments. However, the authors were more interested in including all of the children because 21 of these children had dental disease at the first dental visit even though the mean age for those who had dental caries at their initial visit was 40 months. Other researchers have merged left and interval censored data at the initial oral examination with the rationale that the actual and censored onset are close in time to one another (57).

This study provides that natural course of patient utilization and dental services provided at several health centers in one state within the United States. One of the other strengths of this study is that all participants had continuous enrollment at least up to the time of the first dental visit. Conversely, there are several limitations that must be noted for this retrospective cohort study. First, the study relies on the clinical and radiologic diagnosis of dental caries from participating dentists who were not calibrated. Second, there may be some underestimation of initial dental caries for children who were seen by non-FQHC providers because only dental billed claims data are included for these providers. There may be instances when caries might have been diagnosed but treatment was not rendered. Furthermore, dental x-rays were used irregularly for diagnostic purposes, especially during the child's younger years. Third, the authors were not able to include the 13 children in the regression models who had no birth certificate information. However, there was no statistical difference for dental caries between those with and without birth certificates. Fourth, unfortunately none of the children had been biologically tested by their clinicians for oral microorganisms during the time of study. Lastly, the available statistical tools only allow for one fixed covariate to be incorporated into the regression model along with one time-dependent variable.

In summary, this study showed that there was an association between age at first dental caries for this group of children seen at Federally Qualified Health Centers and the number of dental visits by other children in the household during a 12-month period prior to the subject's first dental visit. Moreover, there is an association between the time-dependent covariate of having longer gaps (months) between dental episodes and having an earlier first dental caries.

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Age (months) at first dental caries (children with caries) or last dental visit (children without dental caries) for five Iowa FQHCs (n=200)

Figure 1.

Age (months) at first dental caries (children with caries) or last dental visit (children without dental caries) for 5 Iowa FQHCs (n=200).

Table 1

Comparison of time-dependent variables between subjects with and without dental caries.

Variable	Caries = Yes %	Caries = No %
Number of fluoride therapies before first dental caries	(n=101)	(n=99)
0	35	5
1	26	28
2	18	19
3	13	16
4	5	9
5	1	9
6 or more	3	14
Number of changes in dental care providers before first dental caries	(n=101)	(n=99)
0	42	49
1	31	27
2	18	14
3	6	7
4	3	3
Number of dental care episodes before first dental caries	(n=101)	(n=99)
0	21	0
1	25	19
2	22	19
3	16	18
4	10	14
5	1	10
6 or more	5	20
Mean of age at first dental caries (subjects with caries) or age at last dental episode (subjects without caries)	(n=101) 52 months (range: 15–97)	(n=99) 49 months (range: 5–102)
Mean of longest gap between dental episodes	(n=80) [§] 19 months (range: 6–57)	(n=80) [§] 17 months (range: 6–47)

[§]Subjects that had only one episode of dental care or had dental caries at the first episode were excluded.

Table 2

Baseline characteristics of child, mother, and family and univariate Weibull regression analysis of non-time-dependent (fixed) variables predicting the hazard ratio of child's first dental caries.

Category	Variable	N	Hazard Ratio (95% CI)	P-value
Child	Gender			
	Female	98	0.778 (0.514, 1.177)	0.235
	Male (Ref)	102	1	
	Race/Ethnicity			
	White, Hispanic	72	1.038 (0.666, 1.618)	0.870
	African-American	38	0.572 (0.295, 1.112)	0.100
	Mixed or other minorities	13	1.667 (0.725, 3.832)	0.229
	White, non-Hispanic (Ref)	78	1	
	Required translator services			
	Yes	52	1.169 (0.748, 1.825)	0.493
	No (Ref)	148	1	
Mother	Age (years) at child's birth *			
	< 20	40	0.751 (0.412, 1.370)	0.351
	20–29	106	0.728 (0.450, 1.178)	0.196
	30 (Ref)	41	1	
	Education at time of child's birth *			
	< 9 th grade (Ref)	36	1	
	9–11 th grade	65	0.924 (0.564, 1.513)	0.752
	12 th grade	58	0.896 (0.531, 1.512)	0.681
	More than high school	26	0.502 (0.198, 1.269)	0.145
	Marital status at time of child's birth *			
	Married	67	1.150 (0.753, 1.757)	0.518
	Single (Ref)	120	1	
Pregnancy/Delivery	Total number of prenatal care visits *			
	10	74	1.193 (0.791, 1.797)	0.400
	> 10 (Ref)	126	1	
	Vaginal delivery mode			
	Yes	134	1.307 (0.782, 2.183)	0.306
	No(Ref)	53	1	
	Tobacco use during pregnancy *			
	Yes	47	0.930 (0.579, 1.492)	0.762
	No (Ref)	140	1	

Category	Variable	N	Hazard Ratio (95% CI)	P-value
Family size	Number of people in household under 21 at time of first dental visit			
	0 (Ref)	45	1	
	1	62	0.928 (0.522, 1.648)	0.798
	2	54	0.952 (0.540, 1.678)	0.864
	3	39	1.493 (0.816, 2.735)	0.194
Health care and dental care visits	Number of subject's well-child visits (WCV) at FQHC before first dental visit			
	0 (Ref)	145	1	
	1	20	0.836 (0.396, 1.762)	0.637
	2	35	0.780 (0.414, 1.468)	0.441
	Number of well adult medical visits at FQHC in household during previous year prior to first dental visit			
	0 (Ref)	90	1	
	1-2	41	0.577 (0.176, 1.895)	0.365
	3	43	0.763 (0.392, 1.487)	0.427
	Number of WCV at FQHC by other children in household during previous year prior to first dental visit			
	0 (Ref)	139	1	
	1-2	18	1.353 (0.685, 2.674)	0.384
	3	43	1.072 (0.670, 1.715)	0.771
	Number of dental visits by adults in household at FQHC during previous year prior to first dental visit			
	0 (Ref)	185	1	
	1	15	0.591 (0.230, 1.520)	0.275
	Number of dental visits at FQHC by other children in household during previous year prior to first dental visit			
	0 (Ref)	158	1	
	1	42	1.711 (1.022, 2.86)	0.041
Center	Federally Qualified Health Center			
	A	40	0.680 (0.356, 1.297)	0.242
	B	40	0.735 (0.401, 1.350)	0.321
	C	40	0.520 (0.252, 1.074)	0.077
	D	40	1.224 (0.668, 2.241)	0.513
	E (Ref)	40	1	

* Available birth certificate information (N=187)

Table 3

Weibull survival models for interval censored data with time-dependent covariates.

Models	Variable	Hazard Ratio (95% CI)	P-value
Model 1	Number of dental visits at FQHC by other children in household during previous year prior to first dental visit	1.271 (1.055, 1.531)	0.012
	Number of subject's dental episodes before dental caries	0.882 (0.741, 1.050)	0.159
Model 2	Number of dental visits at FQHC by other children in household during previous year prior to first dental visit	1.275 (1.058, 1.535)	0.011
	Number of subject's fluoride therapies before dental caries	0.861 (0.722, 1.026)	0.094
Model 3	Number of dental visits at FQHC by other children in household during previous year prior to first dental visit	1.274 (1.058, 1.534)	0.010
	Gaps between subject's dental episodes before dental caries	1.023 (1.007, 1.040)	0.006
Model 4	Number of dental visits at FQHC by other children in household during previous year prior to first dental visit	1.290 (1.071, 1.554)	0.007
	Number of changes in dental care providers before first dental caries	0.970 (0.724, 1.230)	0.839