Original Article

Risk Factors of Dental Caries in the Thai Population: The Retrospective Cohort Study

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ABSTRACT

Aim: The aim of this retrospective cohort study was to determine the risk factors associated with the occurrence of dental caries increments in Thai dental patients. **Materials and Methods:** The dental chart records of 500 patients who visited the Department of Advanced General Dentistry, Mahidol University during 2003–2013 were included in this research. Risk factors such as age, gender, medical history, marital status, routine oral checkup, oral appliance usage, initial and final records of decayed (DT)-missing-filled (DMF-T), dental history of tooth extraction due to caries, xerostomia, presence of visible plaque, presence of interproximal restoration, and caries risk level were retrieved from dental records. Cox proportional hazard regression model was used to determine the association of caries risk factors and new dental caries increments. **Results:** The results indicated that the rate of incidence of new dental caries was 2.1 per 100 person-month. In the multivariate hazard model, past caries experience in more than three teeth (adjusted hazard ratio: 2.29, 95%CI: 1.53–3.44) and xerostomia (adjusted hazard ratio: 4.47, 95%CI: 1.82–10.98) were independent risk factors of dental caries increments. Other factors, such as demographic data, physical factors, clinical factors, and other contributing factors, were not associated with the incidence of new dental caries. **Conclusion:** The presence of past caries experience and xerostomia were predictors of the occurrence of new dental caries.

KEYWORDS: *Caries experience, dental caries increments, risk factors, xerostomia*

INTRODUCTION

Dental caries is a prevalent oral disease that negatively affects the quality of life.[1] This condition can often lead to infections, causing pain and other related oral issues. Therefore, dental caries is a crucial topic that should be included in any discussion on oral health. Dental caries is a condition that arises due to a combination of factors, including nutrition, host vulnerability, and the accumulation of microbes over time. The development of new carious lesions is triggered by the presence of acidogenic microbes, sugar adherence to tooth surfaces, and host sensitivity.[2] Other factors, such as the use of fluoride toothpaste during brushing and social and cultural influences, have a mixed impact on caries development.[3] Therefore, a variety of variables, known as risk factors, have been proposed and evaluated as tools for estimating the prevalence of dental caries.[4] In clinical practice, utilizing a risk assessment for dental caries helps identify patients who are most susceptible to developing the condition over time.

The primary objective of conducting a risk assessment for dental caries is to identify individuals who are at a higher risk of developing caries within a specific time frame. Most multifactor prediction models for caries risk have been designed with a cross-sectional approach, which limits the ability to establish causality between

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variables.[5-7] Abdel Fattah *et al*.[8] studied dental caries in Egypt's population-based survey, analyzing data from 9457 participants. Significant risk factors for dental caries in permanent teeth included age, gender, education level, frequency of dental visits, source of drinking water, and dental anxiety, after adjusting for covariates. However, the study's limitations prevented determining the direction of the association between dental caries and risk factors, and no conclusions about causation can be drawn.

In earlier longitudinal research, logistic regression analysis was commonly used to investigate the relationship between dental caries and various risk factors.[4,9,10] However, participants who did not receive a follow-up are considered as missing data, and logistic regression cannot be used to analyze censored data. Peltzer *et al*. conducted a cohort study on 597 children from Northern Thailand to identify social risk factors for severe early childhood caries (S-ECC). Environmental factors and risk behaviors, such as sleeping with a bottle at 30 months, were associated with S-ECC in multivariate logistic regression analysis. However, the study was limited by potential bias from excluded children who refused or were absent on the day of the dental examination (approximately one-fourth of the recruited pregnant women's children) and those who were examined.[11]

When assessing caries risk, it is crucial to consider the number of caries occurrences and the duration of time at risk. Nevertheless, only a few studies have utilized time-to-event techniques to analyze dental caries.[12,13] In this study, we used an individual's time at risk of developing caries as the unit of analysis in the retrospective survival analysis approach.

The retrospective cohort studies employing secondary data are prevalent epidemiological models probing the relationship between disease risk factors and the incidence of emerging conditions.[14] This approach repurposes existing data to facilitate new research inquiries. This trend is notably prevalent in the field of medical and dental studies.[15-17] For instance, Ito *et al*.[18] employed a retrospective cohort design in 2011 to assess dental patients' caries risk via classification and regression trees. By analyzing data of 442 patients attending an Osaka-based general practice between May 1993 and February 2008, they underscored cariogenic bacteria's pivotal role in caries development, effectively demonstrating CART's individual risk identification. A recent study in 2021 by Muthu *et al*. examined the susceptibility of children to four distinct OXIS contact areas (open [O], point [X], straight [I], and curved [S]) for approximal caries. This historical cohort study utilized patient data from clinical photographs and CBCT images at a private clinic in South Korea, covering January 1, 2014, to August 31, 2015. The findings highlighted the heightened vulnerability of the S-type contact to approximal caries due to its intricate morphology.[19] Analogously, our study harnessed a retrospective cohort design using collected data to delve into individual-level risk factors for dental caries increments, contributing to a comprehensive grasp of caries dynamics.

Materials and Methods

This retrospective cohort study was conducted in compliance with the principle of the Declaration of Helsinki and it was approved by the Ethics Committee of Human Research, Faculty of Dentistry, Mahidol University, Bangkok, Thailand (MU-DT/PY-IRB 2019/062.0309).

Study population

This study conducted a retrospective review of dental records for patients who underwent treatment at the Department of Advanced General Dentistry, Faculty of Dentistry, Mahidol University, Bangkok, Thailand between January 2, 2003, and December 30, 2013. The inclusion criteria for the study were patients aged 18 years or older, availability of information in the dental chart record, completion of dental treatment, and at least one recall visit. The sample size for the study was calculated using the power and sample size function of STATA/BE version 17.0 (Stata Corp., TX, USA) program. A sample size of 458 was used to achieve a hazard ratio of 1.3 with 80% power and a type I error probability of 0.05. To account for incomplete dental treatment records, an additional 10% was included, resulting in a final sample size of 500 charts.

Analysis of dental records

An experienced dentist compiled the dental clinical history data after stripping away the personally identifiable information and instead assigned each participant their own unique number. The date of the patient's oral diagnosis was considered the baseline examination date. The clinical examination, risk factor evaluation at baseline, and duration of follow-up were recorded, along with other variables such as age, gender, medical history, presence of inadequate restoration, marital status, routine oral checkup, oral appliance usage, initial and final record of Decayed (DT)-Missing (MT)-Filled (FT) (DMF-T) dental history of tooth extraction due to caries, xerostomia, occupation, presence of visible plaque, smoking status, presence of restoration at proximal surface of the tooth, and presence of tooth with exposure of root surface and caries risk level.

The patient's risk of developing new dental caries was evaluated using the ADA caries risk assessment form. This form classifies the patient's overall risk of developing new dental caries based on their medical history and physical examination.[15] The form contains three categories of clinical observations for risk factors and preventative factors, which are classified as low, moderate, and high risk.[16]

According to the data in the dental chart recorded at the end of the follow-up period, we classified the outcome into two groups: individuals with and without caries increments. Because of the time gap between the baseline examination and follow-up records, we could not determine the precise time of caries incidence. Therefore, we assumed that the onset of caries increments occurred when it was first recorded in the dental chart, after the complete treatment date. We used the time from baseline examination to final follow-up visits and the time of DT increment to define the survival time.

Statistical analysis

Demographic data were evaluated using descriptive statistics. The relationship between dental caries increments and risk factors for caries was analyzed using the Cox proportional hazard regression model. Hazard ratios (HR) and 95% confidence intervals (95%CI) were calculated for each risk variable. All covariates, including sociodemographic factors, oral health condition, and caries risk level, were considered in the analysis. The software used for analysis was STATA/BE version 17.0 (Stata Corp., TX, USA).

Results

In this study, 500 participants were enrolled. Over a period of 9921 person-months, there were 206 incidences of dental caries, resulting in an incidence rate (IR) of 2.1 per 100 person-months (95%CI: 1.8–2.3). The median survival time was 30 months (95%CI: 26–41) for all participants [Figure 1]. The mean age of the cohort was 51.38 years, with 67.6% (n = 338) female and 32.4% (n = 168) male. Of the 500 participants, 47.6% were married, 52.4% had no medical history of disease, 32.1% had unspecified occupations, 91.4% were nonsmokers, and 78.0% reported receiving regular dental checkups. Table 1 presents the general characteristics of participants with and without dental caries increments. Both groups were similar in terms of gender, age, marital status, occupation, smoking status, medical history, and dental checkup habits.

The oral characteristics of the study participants are presented in Table 2. Overall, 73.4% of participants had undergone tooth extraction due to dental caries, 98.9% had visible plaque, 85.8% had restorations on proximal tooth surfaces, 73.4% had inadequate restorations, 45.6% wore dental appliances, 98.8% did not report xerostomia, 93.2% had a high caries risk, 42.4% had experienced caries in 1–3 teeth in the past, and 55.2% had past DMFT experience of at least 15 teeth. Table 2 also shows the crude HR from univariate Cox regression analysis for each oral characteristic variable. During the recall visit, participants who had experienced dental caries increments were more likely to report xerostomia and past caries experience. The crude HR for developing dental caries increments in patients with xerostomia compared to those without xerostomia was 5.61 (P < 0.001). The crude HR for developing dental caries increments in individuals who had experienced past caries in 1–3 teeth compared to those without past caries experience was 1.91 (P = 0.001), while patients with past caries experience in more than three teeth had a crude HR of 2.44 (P < 0.001). Other oral characteristics were not found to be significantly associated with dental caries increments. Due to the potential presence of confounding variables, further investigation was conducted using multivariate analysis.

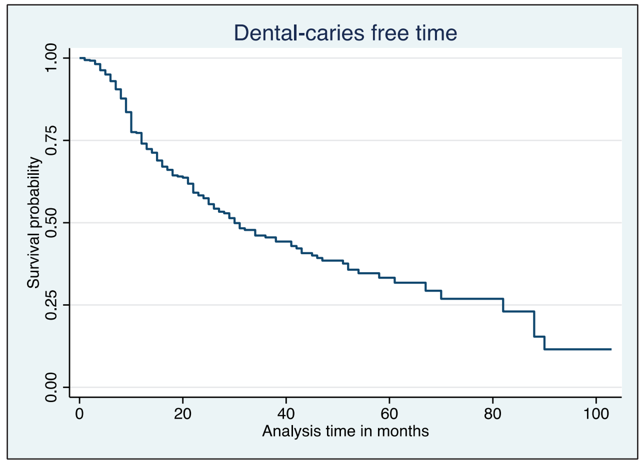

Figure 1: The Kaplan–Meier survival curve for dental caries free time of the population, using the new caries as the event

Table 3 presents the adjusted HR of covariates after multivariate Cox regression analysis. The dental caries increments, after adjustment for covariates including the presence of restorations on proximal tooth surfaces, were significantly associated with xerostomia and past caries experience. Participants with xerostomia had a significantly higher HR for caries increments compared to those without xerostomia, with an HR of 4.47 (95%CI: 1.82–10.98). Meanwhile, participants who had experienced past caries in 1–3 teeth and those with past caries experience in more than three teeth had, respectively, a 1.94 (95%CI: 1.32–2.84) and 2.29 (95%CI: 1.53–3.44) times higher HR for caries increments when compared to participants without past caries experience (no DT).

Table 1: Incidence rates and univariate Cox regression analysis of caries increments according to the general characteristics of all participants (*n* = 500)

Characteristic	Total *n* (%)	Person-month	Incidence *n*	Incidence rate	95%CI	Caries increments No *n* (%)	Caries increments Yes *n* (%)	Crude hazard ratio	*P* value
Gender									
Male	162 (32.4)	3277	62	0.019	0.015–0.024	93 (57.4)	69 (42.6)	Ref	Ref
Female	338 (67.6)	6644	144	0.022	0.018–0.026	178 (52.7)	160 (47.3)	1.14	0.401
Age (years)									
≥60	168 (33.6)	3471	71	0.020	0.016–0.026	93 (55.4)	75 (44.6)	Ref	Ref
40–59	210 (42.0)	4379	82	0.019	0.015–0.023	117 (55.7)	93 (44.3)	0.93	0.641
<40	122 (24.4)	2071	53	0.026	0.02–0.033	61 (50.0)	61 (50.0)	1.24	0.233
Marriage status (*n* = 469)									
Single	204 (43.5)	3876	83	0.021	0.017– 0.027	111 (54.4)	93 (45.6)	Ref	Ref
Married	223 (47.6)	4722	96	0.020	0.017–0.025	118 (52.9)	105 (47.1)	0.96	0.773
Divorce/ separated	42 (9.0)	691	16	0.023	0.014–0.038	22 (52.4)	20 (47.6)	1.05	0.863
Occupation (*n* = 424)									
No occupation	7 (1.7)	61	2	0.033	0.008– 0.131	4 (57.1)	3 (42.9)	Ref	Ref
Laborer	110 (25.9)	2121	42	0.020	0.015–0.027	65 (59.1)	45 (40.9)	0.54	0.398
Government officer	37 (8.7)	731	13	0.018	0.01–0.03	23 (62.2)	14 (37.8)	0.48	0.335
Private company officer	19 (4.5)	294	7	0.024	0.011–0.05	11 (57.9)	8 (42.1)	0.62	0.549
Trader	115 (27.1)	2823	43	0.015	0.011–0.021	65 (56.5)	50 (43.5)	0.41	0.216
Others	136 (32.1)	2549	69	0.027	0.021–0.034	61 (44.9)	75 (55.2)	0.71	0.637
Smoking status (*n* = 440)									
Non smoke	402 (91.4)	8184	160	0.02	0.017–0.023	226 (56.2)	176 (43.8)	Ref	Ref
Currently smoke	38 (8.6)	676	12	0.018	0.01–0.031	22 (57.9)	16 (42.1)	0.90	0.726
Medical history									
No	262 (52.4)	5317	108	0.020	0.017–0.025	138 (52.7)	124 (47.3)	Ref	Ref
Yes	238 (47.6)	4604	98	0.021	0.017–0.026	133 (55.9)	105 (44.1)	1.05	0.745
Regular oral checkup (*n* = 227)									
No	177 (78.0)	3986	65	0.016	0.013–0.021	103 (58.2)	74 (41.8)	Ref	Ref
Yes	50 (22.0)	1269	23	0.018	0.012–0.027	26 (52.0)	24 (48.0)	1.10	0.689

Ref: reference

Discussion

The aim of this study was to identify risk factors associated with dental caries increments. Since dental caries is a multifactorial disease, an appropriate multivariate analysis was necessary to quantify the impact of factors on the incidence of dental caries in the presence of covariates. In cohort studies, survival analyses that consider both censored data and the time before an event occurs are ideal.[20] Furthermore, assessing the prevalence of dental caries at the individual level using survival methods is crucial. Therefore, the use of survival analyses to evaluate risk variables for dental caries while considering censored data and time-to-event occurrence was a strength of this research.

Our study identified prior caries experience and xerostomia as significant predictors of future caries development after adjusting for covariates. These findings are consistent with previous studies that have highlighted the clinical importance of these factors in predicting caries risk.[4,21,22] Chaffee *et al*.[23] conducted a retrospective cohort study using data collected from electronic records at the university instruction clinic to assess the risk factors associated with future caries. The results indicated that the baseline caries risk predicts future caries in this setting. Fan *et al*.[24] investigated the determinants of Early Childhood Caries (ECC) in Beijing, China. They conducted a prospective cohort study involving 712 participating children. The study findings revealed that a history of prior caries experience significantly contributed to the risk of caries development. In a recent study, Hayes

Table 2: Incidence rates and univariate cox regression analysis of caries increments according to oral characteristic of all participants (n = 500)

Characteristic	Total n (%)	Person-month	Incidence n	Incidence rate	95%CI	Caries increments No n (%)	Caries increments Yes n (%)	Crude hazard ratio	P value
Tooth extracted from dental caries (n = 497)									
No	132 (26.6)	2338	48	0.021	0.015–0.027	74 (56.1)	58 (43.9)	Ref	Ref
Yes	365 (73.4)	7510	157	0.021	0.018–0.024	195 (53.4)	170 (46.6)	1.02	0.901
Visible plaque (n = 494)									
No	5 (1.1)	125	2	0.016	0.004–0.064	3 (60.0)	2 (40.0)	Ref	Ref
Yes	452 (98.9)	9162	188	0.021	0.018–0.024	242 (53.5)	210 (46.5)	1.38	0.653
Interproximal restoration (n = 492)									
No	70 (14.2)	1388	21	0.015	0.010–0.023	46 (65.7)	24 (34.3)	Ref	Ref
Yes	422 (85.8)	8397	183	0.022	0.019–0.025	219 (51.9)	203 (48.1)	1.49	0.087
Root surface exposed (n = 472)									
No	157 (33.3)	3004	63	0.021	0.016–0.027	84 (53.5)	73 (46.5)	Ref	Ref
Yes	315 (66.7)	6433	130	0.02	0.017–0.024	172 (54.6)	143 (45.4)	0.99	0.929
Inadequate restoration (n = 493)									
No	131 (26.6)	2503	52	0.021	0.016–0.027	74 (56.5)	57 (43.5)	Ref	Ref
Yes	362 (73.4)	7288	151	0.021	0.018–0.024	193 (53.3)	169 (46.7)	1.00	0.978
Wearing oral appliance (n = 489)									
No	266 (54.4)	5212	103	0.02	0.016–0.024	150 (56.4)	116 (43.6)	Ref	Ref
Yes	223 (45.6)	4582	97	0.021	0.017–0.026	117 (52.5)	106 (47.5)	1.09	0.566
Xerostomia (n = 497)									
No	491 (98.8)	9776	200	0.02	0.018–0.023	268 (54.6)	223 (45.4)	Ref	Ref
Yes	6 (1.2)	50	5	0.1	0.042–0.24	1 (16.7)	5 (83.3)	5.61	<0.001*
Caries risk assessment (n = 497)									
Low to moderate risk	34 (6.8)	527	8	0.015	0.008–0.03	24 (70.6)	10 (29.4)	Ref	Ref
High risk	463 (93.2)	9336	196	0.021	0.018–0.024	246 (53.1)	217 (46.9)	1.41	0.341
Past caries experience (DT) (mean=2.66 ± 0.13)									
0	142(28.4)	3242	38	0.012	0.009–0.016	103 (72.5)	39 (27.5)	Ref	Ref
1-3	212(42.4)	4203	97	0.023	0.019–0.028	108 (50.9)	104 (49.1)	1.91	0.001*
More than 3	146(29.2)	2476	71	0.029	0.023–0.036	60 (41.1)	86 (58.9)	2.44	<0.001*
Past DMFT experience (mean = 15.3 ± 0.34)									
Less than 15	224(44.8)	4480	84	0.019	0.015–0.023	134 (59.8)	90 (40.2)	Ref	Ref
15 or more	276(55.2)	5441	122	0.022	0.019–0.027	137 (49.6)	139 (50.4)	1.19	0.213

Ref: reference.

*Statistically significant at $P < 0.05$

et al.[25] aimed to identify risk indicators for root caries in 334 independently living older adults in Ireland. Using multivariate logistic regression, they found correlations between caries and factors like poor plaque control, two or more teeth with coronal decay, exposed root surface, and xerostomia. Dry mouth, or xerostomia, can cause tooth decay due to reduced saliva production. This increases acidity in the mouth and affects factors that contribute to tooth decay, such as an increase in acid-producing bacteria, a decrease in neutralization ability, mineral loss from teeth, and decreased lubrication. Xerostomia was identified as a significant risk factor for tooth decay.[26] Our study further

Table 3: Multivariate cox regression analysis of risk factors associated with caries increments (*n* = 497)

Factor	Adjusted Hazard Ratio	95%CI	*P* value
Past caries experience (DT)			
None	Reference	Reference	Reference
1–3 teeth	1.94	1.32–2.84	0.001
>3 teeth	2.29	1.53–3.44	<0.001
Xerostomia			
No	Reference	Reference	Reference
Yes	4.47	1.82–10.98	0.001
Interproximal restoration			
No	Reference	Reference	Reference
Yes	1.33	0.83–2.12	0.24

provides evidence of the link between xerostomia, previous caries experience and the likelihood of developing dental caries in permanent teeth.

In this study, the risk factors for dental caries were evaluated at the individual level using survival analysis. Previous studies have emphasized the benefits of using survival analysis to examine longitudinal data.[27,28] As participants have multiple teeth and varied susceptibilities to dental caries, this study evaluated the incidence of caries at the level of the individual as the unit of analysis in survival methods.

Our study employs a robust approach with implications for both clinical practice and future research. By utilizing secondary data and strong statistical techniques, we unveil valuable insights that enhance the field. This methodology offers benefits such as improved time efficiency, cost savings, ethical considerations, and addressing challenges like participant drop-out, which can adversely affect the power of the sample size and potentially introduce type 2 errors that may impact study conclusions. Using the secondary data allows us to overcome prospective study challenges.[14] Unlike typical secondary data pitfalls, our dataset stands out because it was meticulously documented by trained dentists and validated by experienced peers. This collaborative process, coupled with standardized hospital forms, ensures data reliability, effectively addressing quality concerns often encountered in secondary data studies. From a clinical perspective, our results highlight personalized preventive strategies for individuals with a history of caries and xerostomia. Tailored advice, fluoride treatments, and checkups effectively mitigate caries risk. Moreover, our study spurs further exploration of xerostomia's role in caries. Delving into factors such as salivary pH and flow could yield deeper insights.

While our unique data collection inspires confidence in the validity and reliability of our study, setting it apart from conventional secondary data analyses, there are certain limitations. First, dental caries assessments were not calibrated and were conducted by several different dentists, which may have impacted the validity of the acquired data. However, it is important to note that although the dentists were not formally calibrated, they had the same professional training, worked under the supervision of instructors, and utilized standard criteria for detecting and documenting caries. Secondly, the study design may have had limitations, as the researchers were not directly responsible for performing the dental examinations. Nevertheless, this approach may have contributed value, as the treatments and recordings were unbiased toward the study's goals. Lastly, it is worth acknowledging that we did not examine all potential confounding factors that could be related to the development of new dental caries, such as the presence of salivary mutans streptococci, saliva pH, or salivary flow, as these variables were beyond the typical scope of a routine checkup examination.

Conclusion

In conclusion, this study demonstrated that a prior history of caries and xerostomia are significant predictors of future caries development in this population. Therefore, we recommend regular oral examinations to ensure early diagnosis of caries increments, especially for dental patients with a history of caries and/or xerostomia.

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Conflict of interest

There are no conflicts of interest.

Authors contributions

Chanita Tantipoj: Initiation (idea), Conceptualization, Methodology, Data analysis, Data Interpretation, Discussion of the results, Conclusion, Writing-Original Draft. Wifada Powattanasuk: Data Interpretation, Writing-Original Draft. Sirinat Manusrudee: Data collection. Naiyana Buranachad: Initiation (idea), Conceptualization, Methodology, Data Analysis, Data Interpretation, Discussion of the results, Conclusion and Suggestion, Writing-Original Draft. All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Ethical policy and Institutional Review board statement

This study was conducted in compliance with the principle of the Declaration of Helsinki and it was approved by the Ethics Committee of Human Research, Faculty of Dentistry, Mahidol University, Bangkok, Thailand (MU-DT/PY-IRB 2019/062.0309).

Patient declaration of consent

Not applicable.

Data availability statement

Not applicable.

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