Original Article

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Time Until Tooth Loss Among Pre-Elderly Southern Thais under Universal Coverage: A Retrospective Cohort Study

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Abstract:

Objective: This study used dental data to determine the time until tooth loss and its associated factors among pre-elderly individuals aged 45–59 in Southern Thailand.

Material and Methods: A retrospective cohort study was conducted using dental data from 2019 to 2023. The study included individuals under the Universal Health Coverage Scheme who received dental examinations and follow-up care. Tooth loss was defined as permanent tooth extraction (excluding impacted third molars). Data were censored if no extraction occurred by the end of the study or if participants were lost to follow-up. Cox proportional hazards models and Kaplan-Meier analyses were applied with statistical significance at p-value<0.05. Time-varying covariates were also examined.

Results: A total of 4,177 participants were included; 1,582 (37.9%) experienced tooth loss. The overall median time until tooth loss was 40.0 months (95% confidence interval [CI]: 37.9–42.3). Individuals with fewer than 20 teeth, ≥3 decayed teeth, no dental scaling, and aged 55–59 had a shorter median time until tooth loss. Multivariable analysis showed that lack of dental scaling (Hazard rate [HR] 1.53; 95% CI: 1.29–1.81) and ≥3 decayed teeth (HR 1.30; 95% CI: 1.14–1.49) were associated with earlier tooth loss.

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Conclusion: Tooth loss among pre-elderly Thais occurred earlier in those with untreated caries and without dental scaling. These findings highlight the critical importance of timely caries treatment and regular scaling in preserving teeth for long-term function.

Keywords: Electronic health records, pre-elderly, survival time, tooth loss

Introduction

Tooth loss remains a major global health burden. It reflects long-term exposure to dental diseases and access to dental care[1]. While the global prevalence of total tooth loss among individuals aged 60–74 is estimated at over 20.0%[2], the 9th National Oral Health Survey of Thailand (2023) reported a lower rate of 6.2% in the same age group[3]. Despite this, significant tooth loss occurs during the preceding "pre-elderly" period (aged 45–59)[3], while the average number of teeth sharply declines from 28.4 to 18.6[3,4]. This critical transition phase remains under-researched, as national surveys have not specifically targeted this population[3], creating a significant evidence gap for planning effective oral healthcare for Thailand's aging society.

To address this gap, this study utilizes the "43-File standard health dataset", a comprehensive national database from Thailand's Health Data Center containing service utilization and health data for citizens covered by the Universal Health Coverage Scheme (UHCS) since 2015[5]. The UHCS is the main public health insurance program, providing essential healthcare, including primary dental services, to approximately 70.0% of the Thai population[6,7]. While this dataset presents a unique opportunity for longitudinal analysis, time-to-event studies on tooth loss remain limited in Thailand. Therefore, this study aimed to determine the time until tooth loss and identify its associated factors among pre-elderly Thais using this national dataset. The findings will inform early risk management strategies to maintain functional dentition into older age.

Material and Methods

This retrospective cohort study included patients aged 45–59 who accessed dental services in southern Thailand from January 2019 to December 2021. Participants had the UHCS. Dental benefits under the UHCS included fluoride varnish application, scaling, fillings, tooth extractions, surgical removal of impacted teeth, and provision of acrylic-based dentures[6]. Study participants underwent dental examinations and received follow-up care until June 30, 2023. The exclusion criterion was those who had lost all teeth at baseline.

The sample size was calculated based on the method for survival analysis proposed by Rubinstein (1981)[8]. The calculation was performed assuming an exponential distribution of survival times with non-informative censoring, independent entry, and event times. To detect the association between key predictors (number of teeth, decayed teeth, and scaling) and time until tooth loss, a minimum sample size of 1,214 participants was required to achieve a statistical power of 80% at a two-sided significance level of 0.05, based on effect sizes reported in a previous study[9].

Data were extracted from electronic health records, specifically the "43-File standard dataset," which included patient demographics (age, gender), clinical variables (number of teeth, number of decayed teeth), and dental care (scaling during follow-up). The primary event was tooth loss, defined as the extraction of permanent teeth. Surgical removal of impacted third molars was excluded. Tooth loss due to periodontal disease, unrestorable caries, and prosthodontic purposes were included as events. Extractions

for orthodontic purposes and trauma cases were included, but rarely occurred in people aged 45–59 years. Data were censored if the study ended before the event occurred or if the subject was lost to follow-up after receiving dental care during the follow-up period.

Data management and statistical analyses were conducted using R (version 4.3.1) with RStudio[10]. A descriptive analysis of sample characteristics was performed. Survival analysis used Kaplan-Meier, with Log-rank and Peto-Peto tests, to compare hazard rates depending on proportional hazard assumptions. Cox proportional hazard models identified factors associated with tooth loss. Statistical analyses were performed at a significance level of 0.05. Proportional hazard assumptions were tested using Kaplan-Meier curves and assessed by log-log survival plots. Using the likelihood ratio test, variables with a p-value<0.25 were included in the final model. A time-varying covariate approach was applied in the Cox model. Confounding was controlled by adjusting for relevant covariates and using stratified Cox models when necessary. Interaction terms were tested. Only complete cases were included in the analysis. Model performance was assessed using 200 bootstrap resamples. C-statistics evaluated discrimination ability, and calibration was checked via calibration plots and mean absolute error. Data management quality was ensured through a rigorous process of pair programming with an experienced data analyst. This process included cross-checking data extraction scripts, verifying variable definitions, and identifying and resolving logical inconsistencies or potential data entry errors in the raw dataset before analysis. The study was approved by the Human Research Ethics Committee, Faculty of Dentistry, Prince of Songkla University (EC number: 6607-038).

Results

From the initial dataset, 4,177 individuals met the inclusion criteria. Of these, 1,582 experienced tooth loss, while 2,595 did not (Figure 1).

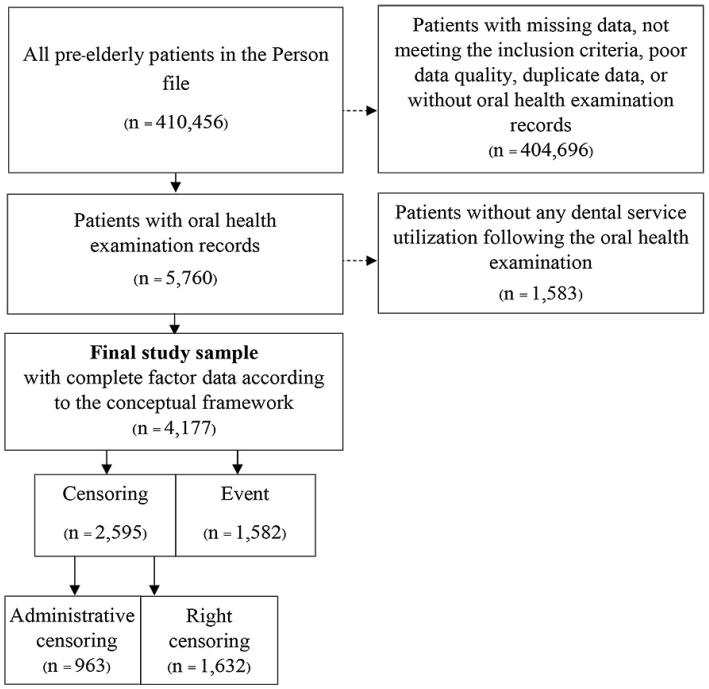

Figure 1 Study flowchart

In the final cohort, 66.2% were female, and the largest age group was 55–59 years (36.1%). At baseline, 24.5% had fewer than 20 teeth, and 34.4% had at least one carious tooth. However, 87.5% did not receive scaling during the follow-up.

During the 54-month follow-up, 1,582 participants experienced tooth loss. Among them, 70.2% were female, and the largest age group was 50–54 years (37.8%). Of those who lost teeth, 30.8% had fewer than 20 teeth, and 39.3% had at least one carious tooth. Additionally, 90.4% did not receive scaling service, as shown in Table 1.

The median time until tooth loss for the entire cohort was 40.0 months (95% CI: 37.9–42.3). Shorter median times until tooth loss were observed among individuals with fewer than 20 teeth (30.4 months), ≥3 carious teeth (33.1 months), and no scaling (38.1 months) (Figure 2). Log-rank and Peto-Peto tests showed significant differences in hazard rates across all factors (Table 2).

The 36-month follow-up multivariable model showed better predictive accuracy than the 54-month model, with a concordance statistic of 0.559 and a mean absolute error of 0.021, making it more reliable for predicting time until tooth loss. Multivariable analysis identified several factors significantly associated with tooth loss: three or more carious teeth (Hazard rate [HR] 1.30, 95% CI: 1.14–1.49), and lack of scaling (HR 1.53, 95% CI: 1.29–1.81) (Table 3).

Discussion

This study addressed a critical research gap by providing the first time-to-event evidence on tooth loss among pre-elderly Thais using a national dataset. The findings indicate a median time until tooth loss of 40.0 months, suggesting a higher and more rapid risk of tooth loss in this population compared to international benchmarks. For instance, a study from the United States following a broader age cohort found that less than 50.0% experienced tooth loss over a 90-month period[11].

One plausible explanation lies in differences in baseline oral health, as the U.S. sample received full-mouth dental treatment prior to follow-up, while this cohort

Table 1 Comparison of factors in the sample group categorized by tooth loss (54-month follow-up)

Factor	Tooth loss/n (%)			p-value[U]
	No tooth loss (n=2,595)	Tooth loss (n=1,582)	Total (n=4,177)	
Gender				
Male	939 (36.2)	471 (29.8)	1,410 (33.8)	<0.001
Female	1,656 (63.8)	1,111 (70.2)	2,767 (66.2)	
Age (years)				
45–49	736 (28.4)	450 (28.4)	1,186 (28.4)	0.023
50–54	886 (34.1)	598 (37.8)	1,484 (35.5)	
55–59	973 (37.5)	534 (33.8)	1,507 (36.1)	
Number of teeth				
≥20	2,059 (79.3)	1,095 (69.2)	3,154 (75.5)	<0.001
<20	536 (20.7)	487 (30.8)	1,023 (24.5)	
Number of decayed teeth				
None	1,780 (68.6)	961 (60.7)	2,741 (65.6)	<0.001
1–2	486 (18.7)	337 (21.3)	823 (19.7)	
≥3	329 (12.7)	284 (18.0)	613 (14.7)	
Received	370 (14.3)	152 (9.6)	522 (12.5)	<0.001
Not received scaling	2,225 (85.7)	1,430 (90.4)	3,655 (87.5)	

[U]=chi-squared test

Table 2 Comparison of tooth loss rates (hazard rate) by each factor

Factor	Hazard rate (1,000 person-months)	p-value
Gender		
Male	18	0.017[a]
Female	20	
Age (years)		
45–49	18	0.022[a]
50–54	19	
55–59	22	
Number of teeth		
≥20	18	<0.001[a]
<20	26	
Number of decayed teeth		
0	18	<0.001[b]
1–2	20	
≥3	25	
Scaling		
Received	13	<0.001[b]
Not received	21	

[a]=Log-rank test used when the proportional hazards assumption is met (i.e., Kaplan-Meier curves are approximately parallel).
[b]=Peto-Peto test used when the proportional hazards assumption is violated (e.g., non-parallel or crossing Kaplan-Meier curves).

Table 3 Factors associated with time until tooth loss within 36 months

Factor	Bivariate		Multivariable model[a]	
	Crude HR (95% CI)	p-value[U]	Adjusted HR (95% CI)	p-value[U]
Gender				
Male	1	0.019	1	0.095
Female	1.14 (1.02–1.27)		1.10 (0.98–1.22)	
Age (years)				
45–49	1	0.019	1	0.319
50–54	1.06 (0.94–1.20)		1.02 (0.90–1.15)	
55–59	1.19 (1.05–1.35)		1.10 (0.96–1.24)	
Number of decayed teeth				
None	1	<0.001	1	<0.001
1–2	1.10 (0.97–1.24)		1.09 (0.96–1.23)	
≥3	1.36 (1.19–1.56)		1.30 (1.14–1.49)	
Scaling				
Received	1	<0.001	1	<0.001
Not received	1.61 (1.36–1.91)		1.53 (1.29–1.81)	

HR=hazard ratio, CI=confidence interval, [U]=likelihood ratio test, [a]=adjusted for gender, age, number of decayed teeth, and scaling. Stratification was applied for the number of teeth due to violation of the proportional hazards assumption (concordance=0.559).

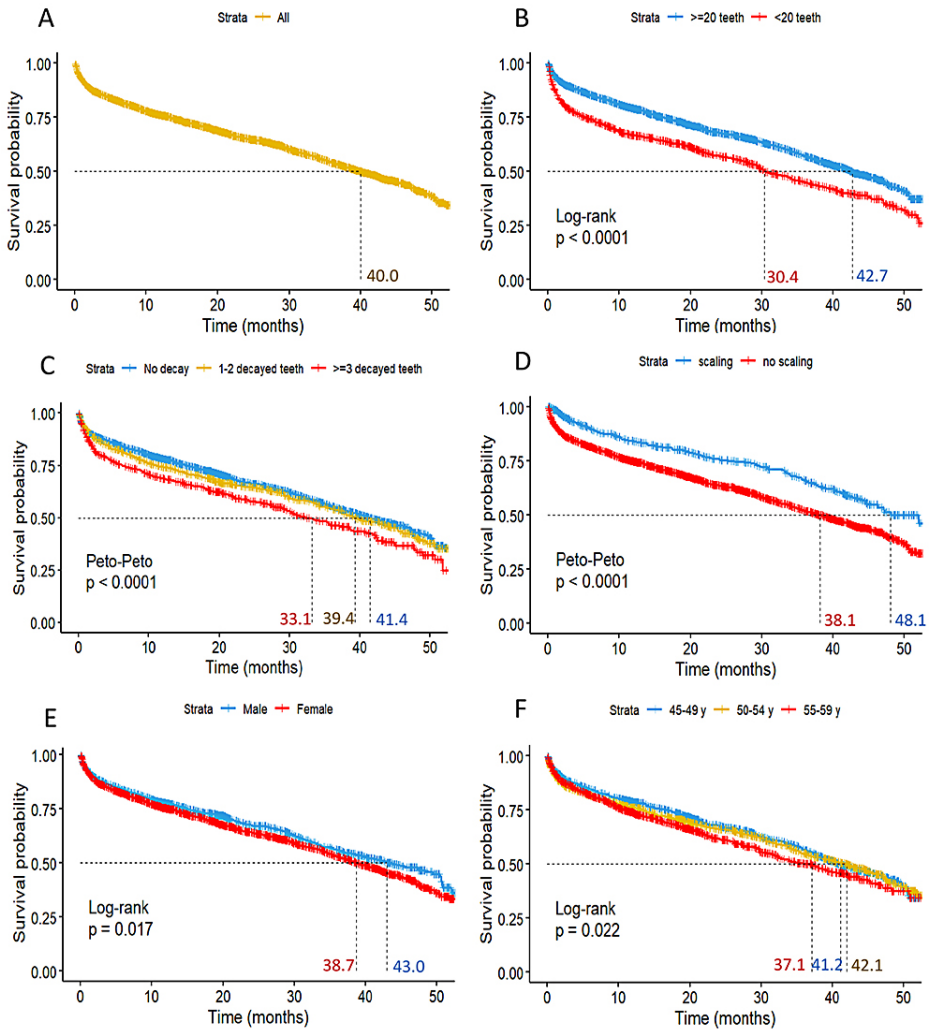

Figure 2 Kaplan-Meier survival curves (A) overall, (B) number of teeth, (C) number of decayed teeth, (D) scaling, (E) gender, (F) age group

began follow-up after an initial dental check-up without comprehensive care. Another explanation is that the study was conducted between 2019 and 2021. At that time, the UHCS benefit package for the pre-elderly population did not include coverage for essential preventive dental care, such as fluoride varnish applications[12], which created a disadvantage for this group. These contextual differences highlight the potential role of timely caries treatment and regular preventive care, such as scaling or fluoride varnish, in delaying tooth loss.

The survival model identified two key modifiable risk factors that significantly shortened the time until tooth loss. The lack of preventive scaling increased the hazard by over 50.0%, while a high burden of untreated caries raised it by 30.0%. These results reinforce the findings of previous studies, such as those by Lee et al. (2019) and

Chen et al. (2012), confirming that both the failure to receive routine preventive care and the presence of active disease are major determinants of tooth loss[11, 13]. It is important to note that these conclusions are drawn from a well-powered study, as our final cohort of 4,177 individuals provided a sample size more than sufficient for a robust time-to-event analysis.

Several limitations must be acknowledged. This study relied on secondary data from the 43-File standard dataset, but many predefined covariates in the conceptual framework were either incomplete or missing. Due to more than 40.0% missing data in key variables, complete-case analysis was applied, which reduced the analyzable sample to approximately 1.0% of the total pre-elderly population. Important variables such as occupation, education, smoking, and removable denture use were either poorly recorded or entirely missing. The variable glycemic control risked misclassification due to incomplete and non-standardized measurement. However, further investigation on diabetes status and HbA1c levels is warranted. Furthermore, the dataset lacked information on overall health status, such as other systemic diseases, pregnancy, or a history of head and neck radiation. As these are known risk factors, their absence prevents adjustment and introduces a risk of unmeasured confounding that may influence the reported hazard ratios. Periodontal status, an important risk factor, could not be directly assessed due to limitations in periodontal probing tools. Instead, scaling service records were used as a proxy. Data quality varied across service providers, partly due to inconsistent definitions and documentation practices. A significant limitation is related to the study's population source.

The analysis included only individuals covered by the UHCS, while those under other schemes, such as the Civil Servant Medical Benefit Scheme and the Social Security Scheme, were excluded. In Thailand, the UHCS is the primary public health insurance, covering approximately 70% of the total population, including the majority of pre-elderly individuals who are not government employees or formal private sector workers[7]. Consequently, this cohort may overrepresent individuals with lower socioeconomic status, who are known to have a higher risk of tooth loss. Therefore, while the findings are highly relevant for the largest segment of the Thai population, they cannot be generalized to the entire nation, particularly to those in higher socioeconomic strata covered by different insurance schemes.

Additionally, this study was conducted in an open cohort. Since external service records were not integrated into the 43-File standard dataset, some dental care events may have been missed, leading to potential underestimation of service utilization and biased survival time estimates. Early events following oral examinations may have inflated hazard estimates, but they reflect real-world clinical practice. Another limitation is the lack of external validation. Therefore, further studies should include external validation to enhance the accuracy and generalizability of the model.

This study demonstrates that the 43-File standard dataset can be effectively used to estimate time until tooth loss, particularly when data are complete and accurate. The findings support the goal of retaining at least 20 functional teeth in pre-elderly individuals and highlight the importance of restorative care for carious teeth, scaling services, and routine dental check-ups every 12 months. The results can inform upstream policy development, guide midstream service-level interventions, and downstream efforts to motivate regular dental visits and preventive oral care.

Conclusion

Among pre-elderly individuals, the median time until tooth loss was 40.0 months (95% CI: 37.9–42.3). Significant factors associated with tooth loss included having ≥3 decayed teeth (HR 1.30, 95% CI: 1.14–1.49) and not receiving scaling (HR 1.53, 95% CI: 1.29–1.81).

In summary, pre-elderly individuals in Southern Thailand who had multiple decayed teeth and did not receive scaling were more likely to experience tooth loss earlier than 40 months.

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Conflict of interest

There are no potential conflicts of interest to declare.

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