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System dynamics analysis of dental caries status among Thai adults and elderly

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Abstract

Purpose – The purpose of this paper is to estimate the changes of dental caries status among Thai adults and elderly under the different policy options using system dynamics modeling.

Design/methodology/approach – A multi-sector system dynamics model was developed to capture the dynamic interrelationship between dental caries status changes and oral health behavior – including self-care, dental care utilization and sugar consumption. Data used to populate the model was obtained from the Thai national oral health survey in 2000, 2006, 2012 and Thailand Official Statistics Registration. Three policy scenarios were experimented in the model: health promotion policy, dental personnel policy and affordable dental care service policy.

Findings – Dental caries experiences among Thai adults and elderly were projected to increase from now to 2040, as the elderly population increases. Among all policies experimented herein, the combined policies of health promotion, increased affordability and capacity of dental health service were found to produce the highest improvement in dental caries status with 3.7 percent reduction of population with high decayed, missing and filled teeth (DMFT) and 5.2 percent increase in population with very low DMFT.

Originality/value – This study is the first comprehensive simulation model that attempts to explore the dynamic interrelationship among dental caries experiences and behavioral factors that impact on oral health outcomes. In addition, the simulation model herein offers a framework for policy experimentation that provides policymakers with additional insights to inform health policy planning.

Keywords Elderly, Adult, Dental caries, System dynamics analysis, Thailand

Paper type Research paper

Introduction

Dental caries is a major public health problem among the adults and the elderly, particularly in developing countries of a nation's population. In Thailand, the prevalence of dental caries among the population aged 15 years, 35–44 years and 60–74 years increased from 62.1 to

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62.7, 85.6 to 91.8 and 95.6 to 98.5 percent between 2000 and 2017[1]. Within this increase, untreated dental caries instances were listed at 40.1 percent (15 years), 43.3 percent (35–44 years) and 52.6 percent (60–74 years) in the 2017 National Oral Health Survey[1]. The presence of dental caries has been found to significantly diminish the oral health-related quality of life of Thais in all age groups[2]. Symptoms of dental caries can cause physical discomfort, psychological stress[3], negative impact on daily activities and a decrease in work productivity[4]. Furthermore, untreated dental caries can eventually lead to edentulism, which limits the ability to chew and may lead to nutritional deficiency and poor physical health[5].

Based on the 2017 Thai Health and Welfare Survey, the proportion of the Thai population who visited a dentist within the past year has increased from 7.4 in 2006 to 9.6 percent in 2017[6]. However, the dental utilization rate is still very low compared to the treatment needs among adults and the elderly[1, 6]. These groups tend to seek dental treatment when the symptoms become more severe[1]. Therefore, treatment for these groups often includes tooth extractions and other complicated and lengthy procedures[1].

The etiology of dental caries is the interaction of multiple factors including the host, oral micro-flora, fermentable sugar in the diet and the length of time an individual is exposed to these factors. Despite individual predispositions to dental caries, other indirect factors such as social, behavioral and environmental factors can increase one's susceptibility to dental caries and their progression[7–9]. In particular, high quantities and frequent sugar consumption are major causes of dental caries[10]. Sugar consumption in Thailand has increased significantly in the past decades from 12.7 kg per person per year in 1983 to 38.2 kg/person/year in 2015[11, 12].

Considering the multiple factors involved in the progression of dental caries and the complex interrelationships among these factors over time[13, 14], addressing changes in dental caries status requires a method that captures these interrelationships and dynamics in a systematic approach. System dynamics is one such methodology[15, 16]. This method has been applied to public health issues such as the outbreak of influenza[17], obesity[18], AIDS and sexually transmitted infections[19]. It has previously been used to analyze oral health problems such as the dental services system in the Netherlands[20], oral health problems of the elderly in urban areas in the USA[21] and manpower needs for dental care in Thailand[22].

Several approaches have been used to improve the prevalence of dental caries in the population worldwide[23]. The WHO Global Oral Health program has adopted oral health promotion which is integrated with the common risk-factors approach (hygiene and diet) as the best means to promote oral health and reduce oral diseases[23]. A systematic review found that an oral health promotion program focusing on daily brushing with fluoride toothpaste effectively reduces dental caries[24]. In Thailand, oral health promotion is integrated within the national dental health policies to help enable the holistic healthcare system to focus on lifestyle changes such as sugar consumption, smoking cessation and tooth brushing with fluoride toothpaste[25]. Furthermore, the use of dental care services was one of the factors affecting the oral health of the population[26]. Baker[27] found that the type of dental services, treatment costs and income of the individual predicted dental treatment needs, which in turn could predict oral health behavior and dental services used. The supply of trained dental personnel was found to be a predictor for dental services utilization for adults in both urban and rural areas[28]. In Thailand, the use of dental services among the elderly was found to be related to attitudes toward oral health conditions, access to dental services, accompanying persons, income and general health conditions[29].

With dental caries, the interrelated factors can adapt to change over time such as with life span and population structures. Although the dental caries problem affects the whole population, the factors related to the development of disease and the dynamics of oral health

behaviors in children are different from adults and the elderly[30]. There is also a cause for concern as the proportion of elderly individuals in Thailand is projected to increase steadily from 13.2 in 2010 to 19.1 percent in 2020 and is estimated to increase further to 32.1 percent in 2040[31]. Oral health problems are also projected to increase[32]. An analysis of determinants affecting oral health shows that these groups are important for understanding the future demands required to adequately plan for dental health services and policy at the population level.

Accompanying this demographic shift is an increased risk of chronic diseases as people age, which can affect the ability to maintain oral hygiene and can lead to certain oral conditions related to the patients' oral mucosa, salivary gland, periodontal tissue and teeth[32, 33]. Moreover, the interaction of related factors may be nonlinear and involve reverse relationships. For example, sugar consumption, self-care and dental treatment can cause a change in a person's dental caries status that can also affect behavior as well. Most traditional studies using epidemiological approaches have analyzed the factors that affect oral health in separate parts. These studies may be limited because they fail to show the dynamic, nonlinear and feedback relationships and may not reflect the impact of other unintended consequences of the problems[14]. The aim of this study was to estimate the changes in dental caries status among Thai adults and elderly under the different policy options using system dynamics modeling.

Methods

This study forms part of a project which aims to analyze the impact of the sugar-sweetened beverage tax on dental caries outcomes in Thailand. This system dynamics modeling project included both qualitative and quantitative elements. The qualitative element was reported earlier elsewhere[34]. It used qualitative processes including extensive literature reviews, in-depth interviews with stakeholders and data analyses, to map the causal relationships between dental caries outcomes, behavioral factors and the sugar-sweetened beverage tax and identified the main feedback loops driving the observed behavior[34].

This study, which formed part of the quantitative model, aimed to project the main outcomes including the number of the population with experience of dental caries in each severity group and the proportion of the population with untreated dental caries in each severity group. Based on the qualitative conceptual framework[34], the system dynamics model was developed using Vensim DSS version 6.4 (Ventana Inc). The model consisted of interacting sets of differential equations developed from a broad range of relevant empirical data to capture the interrelationship of key variables and oral health outcomes. Over the course of the model development process, oral health policy experts were consulted to verify the assumptions and outcome measures. After verification, the model was parameterized using a series of empirical data sets. When data were not available, estimates from experts were used. Finally, the model was simulated to generate the base case and a range of scenarios to project the main outcomes.

Ethical considerations

This study received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Chulalongkorn University, IRB No. 503/59 on September 29, 2016.

Model structure

The quantitative model had three sectors: the population, the dental caries sector and the oral health behavior sector. The projection timeframe was from year 2000–2040. A brief overview of each sector is presented in the below sections.

Population sector. The population sector (Figure 1) modeled the population of Thailand accounting for the aging process of the Thai population and disaggregated the population by age – single year age cohorts and gender[35]. The population sector was calibrated using national statistical data[36].

Dental caries sector. The dental caries sector (Figure 2) disaggregates the Thai population 15 years and older into four dental caries statuses using the decayed, missing and filled teeth (DMFT) index[37]. The DMFT index is an aggregate score of the number of

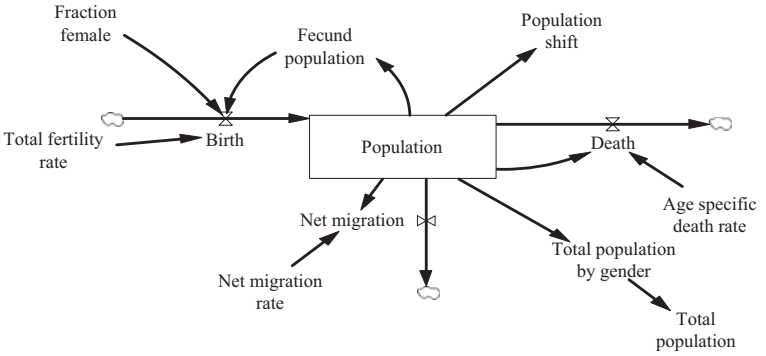

Figure 1.
Population sector

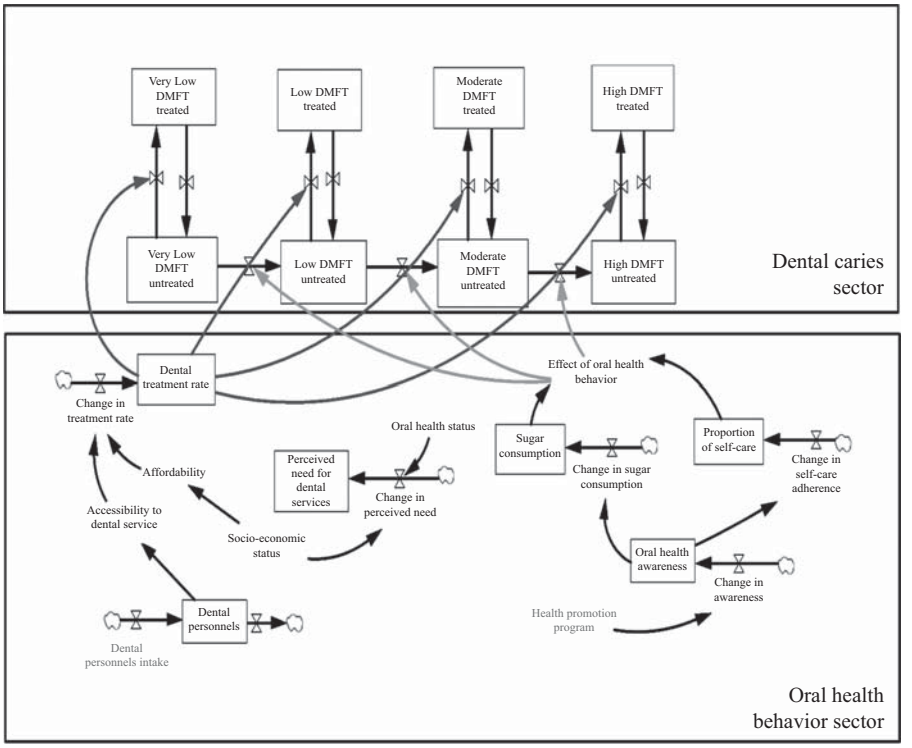

Figure 2.
Combined dental caries sector and oral health behavior sector

teeth that are either decayed, missing or filled. The four dental caries statuses used in the dental caries model are very low DMFT, low DMFT, moderate DMFT and high DMFT; using standards set by the World Health Organization[38]. Each DMFT group was divided into "completely treated" and "untreated," accounting for age and gender differences.

Transitions across dental caries treatment states are influenced by the treatment rate, which is derived from the oral health behavior sector. An increase in treatment rates increases the flow of individuals from untreated to treated dental caries status, whereas a reduction in dental treatment rates will increase the flow of individuals from treated to untreated dental caries status. The transition from low to high DMFT was estimated using available data, adjusting for the effect of oral health behavior. The dental caries prevalence from the Thai National Oral Health Survey in 2000–2001, 2006–2007 and 2012 were the main data sources. At the end of each year, members of the population who reached 15 years of age were moved from the Thai population model (Figure 1) into the dental caries model (Figure 2). The population of 15-year-old was then disaggregated into one of the four dental caries statuses. Subsequently, individuals in each of the dental caries age groups could transition from one dental caries status to another. In this model, dental caries status is assumed to be progressive and only movement from low to high dental caries statuses were allowed.

Oral health behavior sector. Three main factors were identified as key components in the oral health behavior sector including dental treatment rate, the proportion of self-care and sugar consumption (Figure 2). First, the dental treatment rate refers to the number of individuals receiving treatment. The change in treatment rate was influenced by accessibility to dental services, perceived need for dental care and affordability of dental care. Population per dental personnel (dentists and dental nurses) ratio was used as a measure of access to dental services. The supply of dental personnel is usually influenced by the intake of dental and dental nurse students and decreases via attrition. Data on dental personnel were obtained from the Thai Bureau of Dental Public Health, Ministry of Public Health year 2000–2015[37] to populate the model. It was assumed that increased access to dental care would increase the treatment rate.

A perceived need for dental care is assumed to be influenced by the affordability of dental services and oral health status. A proportion of the Thai population considered to be of low socioeconomic status (SES) experience problems with the out of pocket costs for accessing dental care, whereas high SES individuals are assumed to have no such accessibility issues. As the proportion of the population in the high SES group and high dental caries experience increases, the perceived need for dental services is assumed to increase. An increase in treatment rate was assumed to increase the transition between untreated to treated dental caries status (Figure 2).

The other factors in the oral health behavior sector (Figure 2) are sugar consumption and oral health self-care. To estimate the change in sugar consumption, current sugar consumption was compared to sugar consumption in the year 2010 to estimate relative sugar consumption. The self-care practice of oral health was modeled as a stock which changes over time. It is assumed that as health promotion programs increased, oral health awareness was assumed to also increase.

Data sources. Data from the Thailand Official Statistics Registration Systems, Department of Provincial Administration, The Ministry of Interior[36] were used in this model. Fertility rates were obtained from The World Bank Group[39] and mortality rates were obtained from the Thailand Public Health Statistics Report, Bureau of Policy and Strategy, Ministry of Public Health[40]. The Thai national oral health survey data from 2000 to 2001, 2006 to 2007 and 2012 were used to estimate the DMFT distribution, regular visit fraction, the perceived need for dental care and oral health self-care[41]. Average

sugar consumption for the Thai population was obtained from the Thailand Office of the Cane and Sugar Board, Ministry of Industry[12]. A list of model parameters is presented in the Appendix.

Model validation and sensitivity analysis

In order to verify the model's validity, structure-based validation and behavior validation was conducted to ensure that the model was suitable for its purpose. When performing structure-based validation, the dimensional accuracy of the model equations and unit consistency of all variables were checked. The model boundary and assumptions were evaluated by the researchers and experts to ensure its realism and accuracy. On behavior validation, we compared simulated behavior of key outcomes variables – population, dental caries status, dental treatment status and sugar consumption – with available historical data. The results suggest that the simulated behavior compares favorably with data.

Sensitivity analysis was performed to observe how a change in key parameter values would affect the outcomes of interest. The list of parameters used in the sensitivity analysis is shown in the Appendix. Using multivariate sensitivity analysis, the values of each parameter were varied ±20 percent, using a uniform distribution. The model was run many times and a 95% confidence level for each run was used to show the credible interval including mean values.

Scenario analysis

For the purpose of this study, three scenarios in addition to the base-case were explored. These hypothetical scenarios were selected in response to the range of possibilities identified by stakeholders.

Base-case. The base-case scenario assumed that all model parameters and key variables remained unchanged over the simulation run. This simulation served as a reference point for comparing other scenarios.

Health promotion scenario. This scenario encompassed a set of policies aimed to increase oral health self-care and reduce sugar consumption through health promotion programs over the time period of 2018–2040.

Dental personnel intake and affordability scenario. This scenario assumes a gradual increase in the intake of dental students from 933 persons in 2018 to 1,200 persons by 2040. In addition, the proportion of the population considered able to afford dental care services was assumed to gradually increase from 40 percent in 2018 to 80 percent in 2040.

Combined scenario. This scenario is a combination of the health promotion scenario and dental personnel intake and affordability scenario. This scenario aimed to investigate the impact of simultaneously implementing both policy scenarios.

Results

The projected Thai population aged 15 and older by DMFT status is shown in Table I. For the base-case scenario, in 2010, of the 50.4m Thai population members aged 15 years and older, 38.6, 19.9, 16.7 and 24.8 percent had very low, low, moderate and high DMFT, respectively.

Under the health promotion scenario, by 2040 (Table I), the number of individuals with very low DMFT is projected to increase by 0.3m, while that for low, moderate and high DMFT is projected to decrease by 0.03m, 0.02m and 0.2m, compared to the base-case scenario. Compared to the base-case, under the health promotion scenario, the population with very low DMFT is projected to increase by 1.9 percent, while that for low, moderate and high is projected to decrease by 0.3, 0.2 and 1.1 percent, respectively.

Table I.
Projected numbers of population by dental caries status (millions)

Outcomes	2010	2020	2030	2040	% change 2020–2040	% change to base-case
Total population (15 years and older)	50.40	53.36	54.10	52.60	4.4	–
Base-case						
Very low DMFT	9.44 (19.35–19.53)	17.70 (15.56–17.83)	15.63 (15.46–15.79)	13.39 (13.22–13.56)	−31.1	–
Low DMFT	10.03 (9.94–10.12)	10.99 (10.87–11.11)	10.77 (10.64–10.90)	9.81 (9.68–9.94)	−2.2	–
Moderate DMFT	8.41 (8.34–8.48)	9.57 (9.47–9.67)	10.13 (10.02–10.24)	9.89 (9.78–10.00)	17.6	–
High DMFT	12.52 (12.47–12.57)	15.1 (15.01–15.21)	17.57 (17.41–17.72)	19.50 (19.30–19.70)	55.8	–
Health Promotion Program						
Very low DMFT	19.44 (19.35–19.53)	17.35 (17.21–17.50)	15.79 (15.63–15.95)	13.65 (13.48–13.82)	−29.8	1.9*
Low DMFT	10.03 (9.94–10.12)	10.99 (10.87–11.12)	10.74 (10.61–10.87)	9.78 (9.65–9.91)	−2.5	−0.3*
Moderate DMFT	8.41 (8.34–8.48)	9.56 (9.46–9.65)	10.12 (10.00–10.23)	9.87 (9.76–9.98)	17.4	−0.2*
High DMFT	12.52 (12.47–12.57)	15.05 (14.95–15.16)	17.45 (17.30–17.61)	19.29 (19.09–19.49)	54.1	−1.1*
Dental personnel Intake and affordability						
Very low DMFT	19.44 (19.35–19.53)	17.70 (17.56–17.83)	15.63 (15.47–15.79)	13.40 (13.23–13.57)	−31.1	0.1*
Low DMFT	10.03 (9.94–10.12)	10.99 (10.87–11.11)	10.77 (10.64–10.90)	9.81 (9.68–9.94)	−2.2	0
Moderate DMFT	8.41 (8.34–8.48)	9.57 (9.47–9.67)	10.13 (10.02–10.24)	9.89 (9.78–10.01)	17.6	0
High DMFT	12.52 (12.47–12.57)	15.11 (15.01–15.21)	17.57 (17.41–17.73)	19.49 (19.29–19.70)	55.7	−0.1*
Combined scenario						
Very low DMFT	19.44 (19.35–19.53)	17.77 (17.63–17.90)	15.99 (15.83–16.16)	14.09 (13.92–14.26)	−27.5	5.2*
Low DMFT	10.03 (9.94–10.12)	10.99 (10.87–11.12)	10.76 (10.63–10.89)	9.89 (9.76–10.02)	−1.4	0.8*
Moderate DMFT	8.41 (8.34–8.48)	9.56 (9.46–9.65)	10.10 (99.84–10.20)	9.85 (9.74–9.96)	17.1	−0.4*
High DMFT	12.52 (12.47–12.57)	15.05 (14.95–15.15)	17.25 (17.09–17.40)	18.77 (18.57–18.96)	49.9	−3.7*

Notes: Numbers in parentheses refer to a 95% confidence level from the sensitivity analysis for each scenario. *Significant differences

Under the dental personnel intake and affordability scenario, the projections of population ratios in each DMFT group are similar to the base-case and health promotion program scenarios. By 2040, the change in the number of individuals in each DMFT does not show significant differences compared to the base-case scenario, with an exception of 0.1 percent increase observed among the population with very low DMFT and a decrease of 0.1 percent for the population with high DMFT (Table I).

Under the combined scenarios of the health promotion program, dental personnel intake and affordability scenarios, by 2040 (Table I), the individuals with very low and low DMFT are projected to increase by 0.7m and 0.08m, while those with moderate and high DMFT are projected to decrease by 0.05m and 0.7m. By 2040, the combined scenario showed significant differences in the number of individuals in each DMFT group compared to the base-case scenario. By comparing the base-case scenario with the scenario by 2040, the population with very low and low DMFT is projected to increase by 5.2 and 0.8 percent, respectively; while that for moderate and high DMFT is projected to decrease by 0.4 and 3.7 percent.

The proportion of the population with untreated dental caries, representing unmet dental care needs (Table II). In 2010, under the base-case scenario, the proportion of untreated individuals with very low, low, moderate and high DMFT was 63, 91, 92 and 90 percent. In 2040, the proportion of the population with untreated DMFT across all groups is set to decrease compared to 2010. By 2040, the largest percentage decrease of 3.1 percent was observed in the very low DMFT group. For the health promotion scenario, the proportion of the population with untreated caries in all DMFT groups decreased compared to the base-case scenario, with the highest improvement in untreated dental caries status at 9.2 percent observed among the high DMFT group compared to the base-case scenario at year 2040. Under the dental personnel intake and affordability scenario, a similar reduction across all DMFT groups was observed. In 2040, a modest reduction in DMFT status of 0.3 percent was observed among the very low and 0.1 percent for the low DMFT group.

Outcomes	2010	2020	2030	2040	% change 2020–2040	% change to base-case
Base-case						
Very low DMFT	0.63	0.62	0.61	0.61	−3.1	–
Low DMFT	0.91	0.90	0.89	0.89	−1.7	–
Moderate DMFT	0.92	0.91	0.91	0.90	−2.3	–
High DMFT	0.90	0.90	0.90	0.89	−1.0	–
Health Promotion Program						
Very low DMFT	0.63	0.64	0.60	0.59	−5.1	−2.2
Low DMFT	0.91	0.90	0.90	0.89	−1.7	−0.04
Moderate DMFT	0.92	0.91	0.91	0.90	−2.6	−0.4
High DMFT	0.90	0.90	0.83	0.81	−10.1	−9.2
Dental personnel intake and affordability						
Very low DMFT	0.63	0.62	0.61	0.61	−3.4	−0.3
Low DMFT	0.91	0.90	0.90	0.89	−1.8	−0.1
Moderate DMFT	0.92	0.91	0.91	0.90	−2.3	0
High DMFT	0.90	0.90	0.90	0.89	−1.0	−0.01
Combined scenario						
Very low DMFT	0.63	0.62	0.59	0.57	−8.6	−5.7
Low DMFT	0.91	0.90	0.89	0.88	−3.0	−1.4
Moderate DMFT	0.92	0.92	0.91	0.90	−2.4	−0.2
High DMFT	0.90	0.90	0.84	0.84	−7.3	−6.4

Table II.
Projected proportion of untreated dental caries population by DMFT group

For the combined scenario, the untreated dental caries proportion in all groups is projected to reduce; with very low DMFT decreasing by 5.7 percent compared to the base-case; while that of high DMFT had a 6.4 percent reduction.

Discussion

To the best of our knowledge, this is the first comprehensive system dynamics model that attempts to explore the dynamics of dental caries status among Thai adults and the elderly under the potential policy interventions. Among those with dental caries, the proportion with untreated dental caries is expected to decrease slightly over the simulation time, however, more than half of the population aged 15 years and older will still have at least one untreated dental caries by the year 2040. The observed increase in dental caries could be explained by the increasing and aging population[31]as well as low dental care service utilization among the population[6].

Amongst all policy scenarios, the combination of health promotion programs, increased affordability and capacity of dental health services were found to produce the highest improvement in dental caries status by a decrease in population with high DMFT along with an increase in population with very low DMFT. This result showed the additive effect of both positive oral health behaviors and the use of dental services. The model hypothesized that the health promotion program increased oral health awareness and self-care adherence; then it consequently slowed the incidence or progression of dental caries among the population[42]. Evidence from several studies pointed to the positive impact of oral health education and health promotion programs on oral health behavior, such as tooth brushing/flossing and dental care utilization, as well as the attitudes toward oral health[43, 44]. Boles *et al.* [45] also found that health promotion campaigns in the mass media could influence attitudes and behavior about sugary consumption within a population.

Surprisingly, the scenario of increasing 30 percent of dental students and 50 percent of the poverty line population who have financial access to dental treatment would produce only very small changes of the population with untreated dental caries from the base-case. This result might be due to the use of only dental personnel per population ratio as a proxy of capacity for dental health services and leaving other proxies that are not included in our model boundary such as distribution of dental personnel. The increase in dental students' scenario in this study represented the real situation of the increase in new dental schools in recent years. However, the working position in the government sector has been limited and the trend of dentists working in the private sector has been increasing[37]. The increase of dental personnel to population ratio may not translate into an increase of access to dental treatment, especially for the disadvantaged populace within the community. In addition, the increase in affordability for treatment cost showed only a small impact on the treatment rate in the Thai population because the essential dental treatment for low-income groups in Thailand had been subsidized by the universal health insurance scheme[46].

The findings suggested some public health policy implications. First, policymakers should explore interventions that increase oral health awareness among the population through health promotion programs aimed at reducing the incidence and prevalence of dental caries. Second, policymakers should engage other stakeholders in the healthcare system to find innovative ways of increasing affordability among low-income groups and help to educate the public about the value of dental care services for their general health. Finally, in order to improve the utilization of dental care services, access to dental care services should be increased to meet the oral health needs of the population. The policymakers should explore innovative ways to increase dental personnel and dental care services across both rural and urban areas of Thailand to decrease disparity in access.

The inherent strengths of this model are the comprehensive model boundaries adopted which include dental care services utilization, oral health behaviors of the population and its

impact on dental caries status among the Thai population 15 years and older. In addition, the ability of the simulation model to compare different alternative scenarios within the complex oral health system allows policymakers to explore the plausible impact of their policies *in silico* (computer simulation) before they are implemented in order to avoid unintended consequences. The main limitation of the model is the lack of comprehensive data to estimate important parameters that have the potential to change the observed results. Thus, moving forward, further work should be conducted to determine more accurate parameters.

Conclusion

This system dynamics model can be used to explore the relationship between the experience of suffering dental caries, dental service utilization and oral health behaviors in a systematic approach. Policymakers should consider alternative policy interventions that consider both preventive and curative strategies to improve dental caries status in Thailand. Furthermore, the model may be used as an additional tool to inform the types of policies that will prove to be most useful in improving oral health within the country.

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(The Appendix follows overleaf.)

Appendix

Parameter	Initial value		Sources
Population sector			
Fraction female	0.51		Thailand Official Statistics Registration Systems, The Ministry of Interior
Total fertility rate	0.043–0.047		Census reports and data from national statistical offices
Age-specific mortality rate	0.0015–0.058		Bureau of Policy and Strategy, Ministry of Public Health
Net migration rate	0.00058		World bank
Dental caries sector	Age 15–34	Age 35 and older	
Regular visit fraction very low DMFT [female]	0.229	0.148	National oral health survey data 2000; Bureau of Dental Health, Department of Health, Ministry of Public Health, Thailand
very low DMFT [male]	0.191	0.170	
low DMFT [female]	0.306	0.357	
low DMFT [male]	0.308	0.385	
moderate DMFT [female]	0.521	0.643	
moderate DMFT [male]	0.462	0.333	
high DMFT [female]	0.571	0.332	
high DMFT [male]	0.583	0.215	
Treated to untreated transition rate very low DMFT	0.4	0.7	Expert's estimation with optimization
low DMFT	0.78	0.58	
moderate DMFT	0.78	0.34	
high DMFT	0.7	0.75	
[a]VeryLowToLow transition rate	0.063 (0.0504–0.0756)		Model calibration
[a]LowToModerate transition rate	0.066 (0.0528–0.0792)		
[a]ModerateToHigh transition rate	0.063 (0.0504–0.0756)		
Oral health behavior sector			
Initial treatment rate	VL 0.384, L 0.066, M 0.041, H 0.075		National oral health survey data 2000; Ministry of Public Health, Thailand
Initial self-care adherence	0.53		
Initial perceived need for care	VL 0.584, L 0.071, M 0.733, H 0.681		
Dental personnel student	Data from 2000–2015		Report of dental personnel 2000–2015. Bureau of Dental Health, Department of Health, Ministry of Public health, Thailand
Dental personnel			
Attrition rate	0.01		The Dental Council of Thailand
[a]Elasticity of perception of need	VL 0.8, L 0.05, M 0.4, H 0.8		Estimate by dental public health experts and model calibration
[a]Elasticity of affordability	0.1		
[a]Elasticity of sugar consumption	0.6 (0.4–0.72)		

Note: [a]Refer to parameters used for sensitivity analysis

Table AI.
Model key parameters

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