Development of an Oral Salutogenic Checklist to Promote Lifelong Oral Health in Japanese Adults

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Purpose: The aim of this study was to assess the relative weights of each factor related to tooth retention identified in our previous study with an objective of developing a risk assessment tool that could be incorporated into a self-administered oral salutogenic checklist.

Materials and Methods: Oral health status and lifestyle were investigated in 777 subjects aged $\geq$ 20 years. Eleven items that had a statistically significant odds ratio of being related to the number of retained teeth in our previous study were identified. Discriminant analysis was used to calculate the scores for each item.

Results: Based on the discriminant analysis, the variables affecting tooth retention, from the most to the least important, were 'gum swelling' (1.241), followed by 'toothache' (0.766) and 'do you have any hobbies' (0.691). Based on the above analysis, a total of 20 points were allocated in proportion to the ranges. The final oral salutogenic score (OSS) was swollen gums (4), toothache (3), frequency of between-meal snacks (3), having some hobbies (3), having a family clinician (2), consulting a clinician when having dental symptoms (1), bleeding gums (1), frequency of tooth brushing (1), having one's own toothbrush (1) and smoking (1).

Conclusions: A self-administered checklist for the OSS was designed. The first part contains a list of questions for the participants to fill out. The second part offers comments depending on the range of score values. The suggestions include advice to decrease or to stop the behaviours for which the subject obtained zero points.

Key words: behaviours, checklist, salutogenic, tooth loss

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To promote general and oral health, the salient information from studies should be made widely available in an easily understandable format. People require practical measures of risk, based on research, and guidelines on what they can do to change a particular harmful behaviour. In a previous study (Morita et al, 2006a), we assessed the behavioural risk factors that affected tooth retention in later life. The conclusion was that the behavioural factors associated with tooth retention, in the order of their importance, were the frequency of eating snacks between meals, tooth brushing frequency, having one's own toothbrush, smoking and drinking habits, having some hobbies, having a family clinician and when they last had dental treatment. Clinical risk predictors related to tooth retention included having bleeding gums, swollen gums and toothache (Morita et al, 2006a). The objective of the previous study was to develop guidelines that can be used by the public to assess their future risk of tooth loss

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Table 1 Age and gender distribution of the participants

Age (years)	Study participants				Whole village			
	Male	Female	Total	%	Male	Female	Total	%
20–29	7	8	15	1.9	339	258	597	16.5
30–39	49	80	129	16.6	233	264	497	13.7
40–49	107	117	224	28.8	372	347	719	19.9
50–59	94	85	179	23.0	357	298	655	18.1
60–69	97	79	176	22.7	265	284	549	15.2
> 70	36	18	54	6.9	229	373	602	16.6
Total	390	387	777	100	1795	1824	3619	100

so that they can modify the key behaviours to reduce their risk.

There are numerous medical examples of such an approach. For example, some medical institutes and foundations provide information to the public about self-evaluated risks of certain diseases. The American Heart Association (2007) published a risk assessment tool pertaining to heart attacks or deaths due to coronary heart disease in the next 10 years. Coronary prediction charts are recommended by the British Heart Foundation (2007a, b). Likewise, the British National Health Service (2007) lists six lifestyle items to reduce the chances of incurring cancer. This is similar to the US National Cancer Institute (2007) method for calculating the risk of breast cancer using a seven-item questionnaire. A diabetes risk test is used by the American Diabetes Association (2007), and the Harvard Center for Cancer Prevention (2007) has a self-evaluation risk assessment tool for cancer, diabetes, heart disease, osteoporosis and stroke. In Japan, the Japan Health Promotion & Fitness Foundation (2007) has a risk calculator for lifestyle diseases.

The only similar measure for oral diseases to those used for cancer, heart disease and diabetes was developed by the American Dental Association (1988), but this was not based on proper research findings. The ultimate clinical measure of oral health is to maintain at least 20 teeth to the age of 80 years (World Health Organization [WHO], 1982). Therefore, factors that contribute to tooth loss should be assessed to determine the risk of not achieving the above-mentioned goal, that is 20 teeth at 80 years. Numerous factors may contribute to tooth loss (Burt et al, 1990; Kranzler et al, 1990; Locker, 1992; Gilbert et al, 1993; Eklund and Burt, 1994; Drake et al, 1995; Slade et al, 1997; Page et al, 2002, 2003; Kressin et al, 2003; Copeland et al, 2004; Klein et al, 2004; Ylostalo et al, 2004). However, the relative importance of the factors contributing to tooth loss, and therefore in need of being changed, has not been thoroughly investigated. In an earlier paper, we analysed the factors that affected tooth loss in a stable Japanese population (Morita et al, 2006a). In the present study, the objective was to assess the relative weights of each factor and score the eight behaviours and three clinical factors related to tooth retention identified in our previous study, with the objective of developing a risk assessment tool for tooth loss that could be incorporated into a self-administered oral salutogenic checklist.

MATERIALS AND METHODS

Subjects

In this general and dental health survey, 390 men and 387 women of the 3619 residents aged 20 years and above, living in Tobishima, who responded to the call for their annual health checkup recommended by the Ministry of Health, Labour and Welfare, were included. The age distribution of the study group was similar to that of all the residents aged 30 to 60 years except that people in their 20s and $\geq$ 70 years were under-represented in the study (Table 1).

This study was approved by the Ethics Committee of Aichi Gakuin University.

Questionnaire and examinations

The subjects were asked to complete the questionnaires concerning their past diet and lifestyle. The

Table 2 Questions and responses at different stages of life

Questions	Responses at different periods of life	Options
Q1 Preferred intake of sweet foods	ES, JHS, 20, 30, 40, 50 years	Yes/moderate, no
Q2 Tries not to eat sweets	ES, JHS, 20, 30, 40, 50 years	Yes, moderate/no
Q3 Frequency of between-meal snacks	ES, JHS, 20, 30, 40, 50 years	Always/sometimes, never
Q4 Frequency of tooth brushing	ES, JHS, 20, 30, 40, 50 years	2 or more times/ 1 or fewer times
Q5 Do you have your own toothbrush?	20, 30, 40, 50 years	Yes/no
Q6 Smoking	20, 30, 40, 50 years	Yes/no, quit
Q7 Alcohol	ES, JHS, 20, 30, 40, 50 years	Yes/no
Q8 Do you have any hobbies?	ES, JHS, 20, 30, 40, 50 years	Yes/no
Q9 At least one dental clinic near your house	ES, JHS, 20, 30, 40, 50 years	Yes/no
Q10 Do you have a family clinician?	ES, JHS, 20, 30, 40, 50 years	Yes/no
Q11 Consults a clinician as soon as dental symptoms appear	ES, JHS, 20, 30, 40, 50 years	Yes/no
Q12 Gums bleeding	20, 30, 40, 50 years	Frequently, occasionally/seldom
Q13 Gum swelling	20, 30, 40, 50 years	Frequently, occasionally/seldom
Q14 Toothache	20, 30, 40, 50 years	Frequently, occasionally/seldom
Q15 Do you have your teeth scaled?	20, 30, 40, 50 years	Frequently, occasionally/seldom

ES: Elementary school student; JHS: junior high school student; 20, 30, 40, 50 years: when you are/were 20/30/40/50 years old; underlined: reference options for odds ratio.

questionnaire was mailed to each participant and, once completed, was collected at the time of health examinations. Of the 40 questions, 15 were used in this study to investigate lifestyle and oral symptoms relevant to tooth retention (Mizuno et al, 1993; Morita 1996). The 15 questions included the subjects' preference for sweet foods including confectionary, the number of between-meal snacks they had per day, smoking and drinking habits, presence of toothache, gum swelling, gum bleeding and attitudes towards dental checkup (Table 2). The participants were asked about their behaviour at different stages of their life; when they were in elementary school, junior high school and when they were in their 20s, 30s, 40s and 50s. The questions and optional answers are presented in Table 2.

Oral health examinations by clinicians were done using pre-established WHO (1987) criteria.

Statistical analysis

The results of our previous study are given in Table 3 (Morita et al, 2006a). Eleven items that had statistically significant odds ratio (OR) of being related to the number of retained teeth were identified. Multivariate analysis was used for calculating the effects of each item for retaining teeth, after adjusting for the effects on other items. Criterion variables were binary variables such as 1 when at or above the cut-off point and 0 when below the cut-off point. The cut-off points were calculated from the average number of retained teeth for each 10 years of age and gender group (Table 4). The explanatory variables used the 11 items that had statistically significant OR. Each item was changed to a binary variable. Some multiple-choice items and choices that were rarely chosen were combined. Discriminant analysis was used for multivariate analysis. Binary variables of criterion variables and quantitative data of explanatory variables were used for the discriminant analysis. Qualitative data of explanatory variables were changed to dummy variables. Quantification Method II that was developed and validated by Hayashi (1952) was used to calculate the category scores that are the normalised discriminant coefficients. They ranged from the minimum to the maximum category score of each explanatory variable. The ranges show the strength of the explanatory variable (Hayashi, 1952).

RESULTS

Scores derived from the discriminant analysis

Based on the discriminant analysis the variables affecting tooth retention, from the most to the least important, were 'gum swelling' (1.241), followed by 'toothache' (0.766), 'do you have any hobbies'

Table 3 The oral health-related questions and items used for discriminant analysis

Age (years)		Items														
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
Adoption of items		x	x	√	√	√	√	√	√	x	√	√	√	√	√	x
Male	All ages	–	–	–	1.55	2.11	–	–	–	–	–	–	2.03	2.27	2.28	–
	30–39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	40–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	50–59	–	–	–	3.98	–	–	11.96	–	–	–	–	–	–	–	–
	60–69	–	–	–	–	–	–	–	–	–	–	–	–	–	3.39	–
	70–79	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	> 30	–	–	–	1.56	2.07	–	–	–	–	–	–	2.02	2.19	2.18	–
	> 40	–	–	–	1.93	1.97	–	–	–	–	–	–	2.02	2.16	2.00	–
	> 50	–	–	–	3.25	–	2.71	–	–	–	–	–	1.83	2.13	–	–
	> 60	–	–	–	2.41	–	–	–	–	–	–	–	–	–	2.38	–
Female	All ages	–	–	1.81	–	–	–	–	–	–	–	1.72	–	2.04	–	–
	30–39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	40–49	–	–	2.24	–	–	–	3.83	–	–	2.34	–	–	3.04	3.52	–
	50–59	–	–	–	–	–	–	–	2.97	–	–	–	–	–	–	–
	60–69	–	–	4.67	–	–	–	–	–	–	–	–	–	–	–	–
	70–79	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	> 30	–	–	1.81	–	–	–	–	–	–	–	1.74	–	1.93	–	–
	> 40	–	–	2.25	–	–	–	–	–	–	–	–	–	2.34	–	–
	> 50	–	–	2.40	–	–	–	–	–	–	–	–	–	2.02	–	–
	> 60	–	–	4.08	–	–	–	–	–	–	–	–	–	–	–	–

Q1	Preferred intake of sweet foods	Yes/(moderate, no)
Q2	Tries not to eat sweets	(Yes, moderate)/no
Q3	Frequency of between-meal snacks	Always/(sometimes, never)
Q4	Frequency of tooth brushing	2 or more times/(1 or fewer times)
Q5	Do you have your own toothbrush?	(Yes)/no
Q6	Smoking	Yes/(no, quit)
Q7	Alcohol	Yes/(no)
Q8	Do you have any hobbies?	(Yes)/no
Q9	At least one dental clinic near your house	(Yes)/no
Q10	Do you have a family clinician?	(Yes)/no
Q11	Consults a clinician as soon as dental symptoms appear	(Yes)/no
Q12	Gums bleeding	Frequently, occasionally/(seldom)
Q13	Gum swelling	Frequently, occasionally/(seldom)
Q14	Toothache	Frequently, occasionally/(seldom)
Q15	Do you have your teeth scaled?	(Frequently, occasionally)/seldom

Only a significant OR at 95% CI is shown.
√: Items adopted for multivariate analysis; x: items left out of further analysis; /: options used in statistical analysis; –: not significant.
The items in brackets are references (OR = 1).
The outcome variable was coded 1: at or above cut-off point; 0: below cut-off point. The cut-off points varied according to age and gender group.

(0.691) and 'frequency of between-meals snacks' (0.660). The discriminant analysis using the partial correlation coefficients (Table 5) had correctly predicted 59.8% of tooth retention.

Based on the above analysis, a total of 20 points were allocated in proportion to the ranges (Table 5). Points obtained were rounded off to whole numbers. Because the sum of all whole numbers was 21 points, 1 point was subtracted from the score of 5 points, the highest score that was allocated to 'gum swelling', to adjust the total score to 20. This 'adjusted score' gives the final scores of the items included in the oral salutogenic score (OSS) system. The final scores were swollen gums (4), toothache (3), frequency of between-meal snacks (3), having some hobbies (3), having a family clinician (2),

Table 4 Average number of teeth for cut-off points		
Age (years)	**Males**	**Females**
20–29	28	28
30–39	28	28
40–49	27	27
50–59	24	24
60–69	18	21
> 70	14	16

consulting a clinician when having dental symptoms (1), bleeding gums (1), frequency of tooth brushing (1), having one's own toothbrush (1) and smoking (1). Alcohol consumption was excluded from the list of OSS, because it scored < 1 point after rounding to a whole number.

Distribution of OSS

Using the OSS system, scores were obtained for each subject. The mode was 9 points, and the average value was 9.6 ± 3.8 points (mean ± SD).

Self-administered checklist

On the basis of the scores obtained, a self-administered checklist for the OSS was designed (Fig 1). The first part contains a list of questions for the participants to fill out. The second part offers comments depending on the range of score values. The suggestions include advice to decrease or to stop the behaviours for which the subject obtained zero points.

DISCUSSION

Tooth loss is caused mainly by dental caries and periodontal diseases (Morita et al, 1994). Their development and progression are affected by many factors (American Dental Association, 1988; Burt et al, 1990; Kranzler et al, 1990; Locker, 1992; Gilbert et al, 1993; Eklund and Burt, 1994; Drake et al, 1995; Page et al, 2002, 2003; Kressin et al, 2003; Klein et al, 2004; Morita et al, 2006b). For such multifactorial diseases such as caries and periodontal disease, multivariate analysis is a useful tool to assess the effect of each factor. Quantification Method II is a type of multivariate discrimination analysis used when both a criterion variable and an explanatory variable are the categorical data (Hayashi, 1950, 1952, 1954). It is a method of multivariate discrimination analysis expanded to manipulate attribute data as predictive variables (Suzuki and Kudo, 1979). This analysis is used for the discrimination, prediction and evaluation of predictive variables. In medical research, the Quantification Method II analysis is used to investigate the causes of the diseases (Yamaoka et al, 1988) and to evaluate the effectiveness of treatments (Nakajima, 1976; Akagi et al, 1988).

Because lifestyle is difficult to quantify, most studies report results in the form of qualitative or categorical data. When an explanatory variable is categorical, then Quantification Method II and logistic regression analyses (Armitage et al, 2002) can be used as multivariate analyses. Logistic regression analysis is commonly used in medical research and, like Quantification Method II, is effective for constructing models to discriminate and to predict diseases.

The advantage of using Quantification Method II is that it is a form of multivariate discrimination analysis; this method adjusts for many confounders. This explains why the order of importance of behavioural factors associated with tooth retention in the previous study (Morita et al, 2006a) differed from those in the present study. For example, in the previous study where only OR was used, the frequency of eating snacks between meals, tooth brushing frequency and smoking and drinking habits had the highest OR. In the present study, the main variables affecting tooth retention in the same study population as the previous study, were gum swelling, followed by toothache, having hobbies and the frequency of eating snacks between meals.

In developing an index for examining health status, minimising the number of questions and evaluating their validity are important (McDowell and Newell, 1996). This suggestion was applied to the design of a workable questionnaire. The goal of the current study was to develop an index that could be widely used by the population. We chose explanatory variables according to OR, because Quantification Method II does not allow the automatic selection of explanatory variables.

The advantage of developing an oral risk estimator is that it is composed of answerable items without clinical examination by professionals, and all the risk factors should be amenable to improvement. Factors that cannot be changed are not included. Therefore, although age (Eklund and Burt, 1994; Page et al, 2002), gender (Slade et al, 1997; Susin et al, 2005) and caries experience (Eklund and Burt, 1994; Slade et al, 1997; Worthington et al, 1999)

Table 5 Process of allocating scores using discriminant analysis (Hayashi's Quantification II)

Questions	Options	Partial correlation coefficient	Range	Score proportional to range[a]	Rounded off values	Adjusted score
Q3 Frequency of between-meal snacks			0.660	2.6	3	3
	Sometimes, never	0.408				
	Always	−0.252				
Q4 Frequency of tooth brushing			0.350	1.3	1	1
	2 or more times	0.204				
	1 or fewer times	−0.146				
Q5 Do you have your own toothbrush?			0.367	1.4	1	1
	Yes	0.336				
	No	−0.031				
Q6 Smoking			0.148	0.6	1	1
	No, quit	0.081				
	Yes	−0.067				
Q7 Alcohol			0.072	0.3	0	
	No	−0.041				
	Yes	0.031				
Q8 Do you have any hobbies?			0.691	2.6	3	3
	Yes	0.509				
	No	−0.182				
Q10 Do you have a family clinician?			0.446	1.7	2	2
	Yes	0.111				
	No	−0.335				
Q11 Consults a clinician as soon as dental symptoms appear			0.363	1.4	1	1
	Yes	0.248				
	No	−0.115				
Q12 Gums bleeding			0.140	0.5	1	1
	Seldom	0.046				
	Frequently, occasionally	−0.093				
Q13 Gum swelling			1.241	4.7	5	4
	Seldom	0.438				
	Frequently, occasionally	−0.802				
Q14 Toothache			0.766	2.9	3	3
	Seldom	0.147				
	Frequently, occasionally	−0.619				
				Total	21	20

[a]A total of 20 points were distributed in proportion to range.

are good predictors for tooth loss, they cannot be changed and are not included in our OSS system.

The current study found that the factors affecting tooth retention could be weighted by their relative importance. A high OSS predicts low risk of future tooth loss. The role of this score is to highlight the factors important for the individuals to maintain oral health for their lifetime. This approach uses the concepts developed by Antonovsky (1979, 1993) when formulating the salutogenic approach. The salutogenic approach analyses the factors that contribute to health in people who are 'healthy' rather than assessing what makes people sick, so as to predict future health. In the present study, two symptoms of oral disease, namely swollen gums and toothache, were good predictors of retaining teeth.

We found a positive relationship between the preference for sweet foods and the number of remaining teeth at all stages of the life course (Morita et al, 2007). The preference for sweet foods had a high score (3) in the OSS system. The item 'do you eat between meals' may be related with consuming sweet foods frequently. This item was an important predictor in female subjects.

Oral salutogenic score

Items	Please circle YES or NO YES	NO
Do your gums swell sometimes?	0	4
Do you sometimes have toothache?	0	3
Do you often eat between meals?	0	3
Do you have any hobbies?	3	0
Do you have a family clinician?	2	0
Do you go to a clinician soon after you have a toothache?	1	0
Do your gums bleed sometimes?	0	1
Do you brush your teeth at least twice a day?	1	0
Do you have your own toothbrush?	1	0
Do you smoke?	0	1

Add up the numbers you have circled Total ( ) + ( ) = ( ) points

16 and above

Your current lifestyle is good for your oral health, and your teeth seem to be healthy. Try improving the condition. Try to do something about items with "0" points.

11 to 15

Your current oral condition and lifestyle will cause trouble for your oral health. Review your lifestyle to maintain healthy teeth. Try to do something about items with "0" points.

10 and below

Your current oral condition and lifestyle are not good for your oral health. You should review your lifestyle and have a dental checkup of your teeth. Try to decrease the number of items with "0" points.

Fig 1 Oral salutogenic score: self-administered checklist.

Stress contributes to various diseases and is reportedly associated with tooth loss (Jones et al, 2003). Having a hobby, a factor that is related to tooth loss (Morita et al, 2006b), may reduce stress, and stress affects periodontal status (Sheiham and Nicolau, 2005).

Eklund and Burt (1994) had reported that poor general and oral health and the absence of regular dental visits were strongly associated with the risk of tooth loss; this is a finding confirmed in the present study. Eklund and Burt (1994) had also reported that tooth loss was correlated with higher periodontal disease scores, perceived poor dental health and a history of smoking in younger people. Although the ADA recommended brushing the teeth twice daily and flossing at least once a day, and having regular prophylactic dental visits (American Dental Association, 1988; Kressin et al, 2003), these items did not score high in the present study.

Smoking was apportioned only 1 point in the OSS system. This fits with our finding that smoking had a minimal influence on the number of teeth retained at 80 years of age. However, the group of non-smokers and those who quit smoking had more than 20 teeth compared with those who smoked from ages 20 to 60 years (Morita et al, 2007).

The OSS is based on retrospective data. Therefore, a prospective study is needed to verify its reliability as a screening tool. For this reason, we are performing a followup study of the participants who took part in the present study.

CONCLUSIONS

A self-administered checklist to be used by lay people to prevent tooth loss was developed using multivariate analysis. The scores depend on the discriminant coefficient of the relation of oral health-related behaviours and symptoms of oral disease to tooth retention. The most important factor related to retaining the teeth was not having swollen gums (score 4). Toothache, frequency of between-meal snacks and having some hobbies scored 3. Having a family clinician scored 2. Consulting a clinician when dental symptoms occur, bleeding gums, frequency of tooth brushing, having one's own toothbrush and smoking scored 1. The system needs to be tested on a range of populations.

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