Risk factors related to the reduction of subjective taste ability in middle- to old-aged nursing home residents in Sri Lanka: a cross-sectional study

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Abstract

The purpose of this study is to verify the factors significantly related to the reduction of subjective taste ability of 1,015 middle-aged and elderly (50 - 96 years old) at 25 randomized selected nursing homes in Sri Lanka. Binary logistic regression analyses by gender were performed using IBM SPSS on following variables. A dependent variable is taste ability, and 27 independent variables are age, daily lifestyle, nutritional problems, general status, dental status and physiological thresholds of taste abilities (sweet, salt, sour, bitter, and umami). Smell ability ($p < 0.001 - 0.05$) and the Self-Report Questionnaire, 20-item version :SRQ 20 ($p < 0.01 - 0.05$) were significant risk factors of reducing taste ability in both genders. Especially, smell ability was closely linked to taste ability. Existence of comprehensive perception of "flavor" composed of taste and smell ability was illustrated. Significant gender differences factors were observed in long term care needs ($p < 0.05$), sleeping ($p < 0.01 - 0.001$), bowel condition ($p < 0.05$) in males; and height ($p < 0.05$), weight ($p < 0.05$), BMI 3 categories ($p < 0.05$), and brushing ($p < 0.05$) in females. Other variables such as age and five types of physiological taste ability were not significant in both genders. The results of this investigation also strongly indicated that the perception of subjective sense of taste was different from the objective sense of taste.

Epidemiological studies such as cohort or intervention studies focusing on a relationship between subjective taste ability and sense of smell are necessary to identify more accurate and changeable risk factors for dysgeusia in order to improve elderly's nutritional intake in Sri Lanka.

Introduction

The WHO Oral Health Programme [1] encourages public health care administrators and decision-makers to design effective and affordable strategies and programs for better oral health and quality of life of the elderly, which can

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be integrated into general health programs.

The reduction of subjective taste ability has been clinically found among people with mental or physical disorders/diseases [2,3] or nutritional abnormality such as zinc deficiency [4]. The characteristics of sex, age, lifestyle, etc., make it difficult to consider preventive measures for the reduction of subjective taste ability in the public health.

The authors performed the pilot study [5] on the taste ability of about 200 elderly residences of nursing homes in Sri Lanka. The study showed that a lot of factors such as sex, age, a level of long-term care need, bowel movement, and blood pressure complicatedly affected a subjective taste and sense of deliciousness. Then, five types of objective taste (sweet, salty, sour, bitter and umami) test using the physiological tests [6] were conducted to about thousand participants in nursing homes in Sri Lanka. The result of the Poison regression analysis on the relationship between underweight and five types of objective taste sensitivities showed that only low taste sensitivity to bitter taste was related to the underweight of the elderly residences.

The purpose of this study was to verify the factors significantly related to the reduction of subjective taste ability of the middle to old aged nursing home residences in Sri Lanka while adjusting for background factors, such as age, daily lifestyle, nutritional problems, general status, dental status and physiological thresholds of taste ability, which have been identified in previous studies [2,5,6].

Outcomes of this study will contribute to the integration of dental health programs into general health programs in order to seek for effective preventive measures for the reduction of subjective taste ability, which may be related to QOL and ADL of the middle-aged people and elderly in Sri Lanka.

Eventually, quality of health policies for the elderly can be remarkably improved by strengthening medical and dental collaboration through interdisciplinary studies on such field as taste ability.

Subjects and Methods

1. Cause and Effect Diagram (Fishbone Diagram)

Figure 1 shows Cause and Effect Diagram (Fishbone Diagram) [7] for the reduction of subjective taste ability. Eight hypothetical main causes and 27 sub-causes for the reduction of subjective taste ability were selected from previous studies [8-13] and our previous studies [5,6] in Sri Lanka. Eight causes are gender differences, age, daily habits, nutritional problems come from feeding services at each nursing home, physiological thresholds of taste ability, dental status, general status and physiological status.

According to previous relevant studies, gender differences, age, daily lifestyle, nutritional problems come from feeding services at each nursing home, physical status (general status, dental status, five elements of taste ability) were listed up as main risk factors for the reduction of subjective taste ability. Twenty six hypothetical sub-risk factors excluding gender differences in the Fishbone Diagram were used as independent factors in the binary logistic regression analyses (b-LRAs).

2. Participants (after missing imputation)

This cross-sectional study was conducted from July 2010 to August 2011. Twenty five facilities with 25 or more residents located in three districts (Colombo, Gampaha and Kaltutara) of Western Province, Sri Lanka, were randomly selected from 97 nursing homes registered with the Social Service Department of Western Province. The facilities are funded by combinations of governmental subsidies, private donations and pensions; and administered by a non-government organization (NGO). A total of 1,062 (78.1%) of 1,360 residents, aged 50 - 96 years, from 25 nursing homes participated in this study.

Percentage of missing cells was 0.53% of total data cells (1,062 records, 59,160 cells). Forty seven records were deleted from 1,062 records on condition that over three missing cells or missing record having taste ability in each record. The estimation by multiple regression model using cold-deck missing imputation [14] was applied to remaining records with missing values using IBM SPSS 21 statistics. Consequently, 1,015 persons including imputed 160 records were confirmed as participants of this study.

3. Data analyses

(1) Software for analyses

Microsoft Excel 2013 SP2 and IBM SPSS statistics 21 were used for data analyses.

(2) Taste ability: dependent variable

Taste ability was consolidated into two categories and used as the dependent variable in b-LRAs.

(3) Independent variables

Column named "Characteristics of variable" of Table 1 shows types of scale and categories for 27 independent variables identified as risk factors reducing taste ability based on Figure 1.

(4) Basic statistics

Types of numeric variable [15] are composed of continuous variables (such as height) and discrete variables (such as the total number of present teeth). Types of categorical variable [15] are composed of ordinal variables (qualitative variables such as smoking habit) and nominal variables (such as bowel movement). Categorical variables were compared using Chi-square test. Peripheral categories were consolidated into one category when more than 20% of cells with an expected count less than five were observed. Student's t tests were applied to compare gender differences of numeric variables with equal-variance, whereas Welch's t tests were applied to those with unequal variance.

(5) binary logistic regression analyses (b-LRAs)

Backward-b-LRAs using a value of -2 Log Likelihood (-2LL) as the criteria for eliminating insignificant variables one after another up to the optimum goodness-of-fit [16] model by gender were performed, and the backward procedure was repeated until the χ^2 value for the difference of

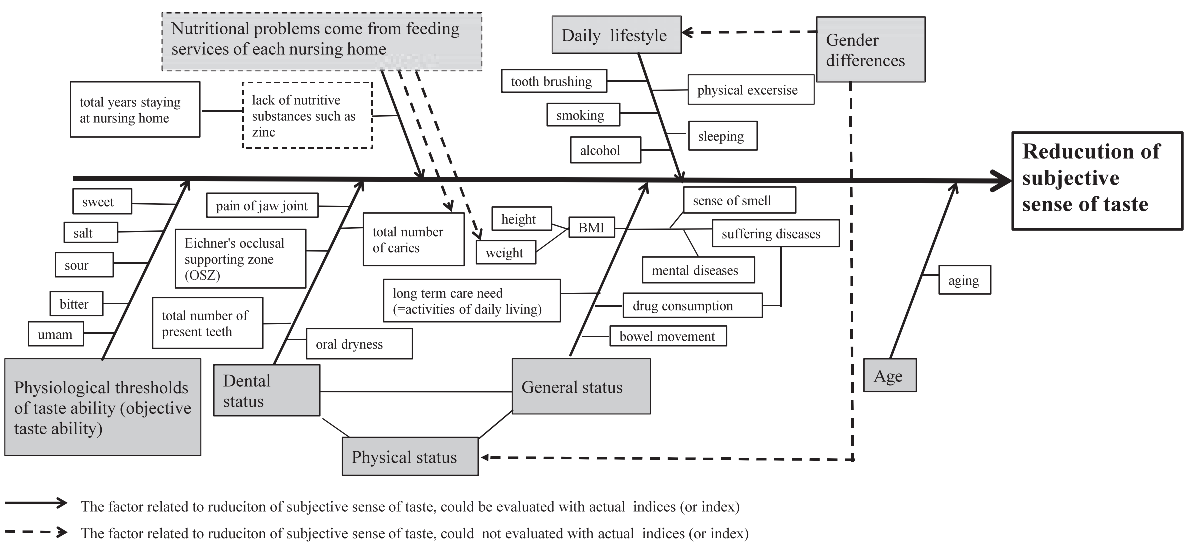

Figure 1. Cause and Effect Diagram (Fishbone Diagram) for risk factors to reduce subjective taste ability

Table 1. Basic statistics of dependent and independent variables for binary logistic regression analyses by gender

characters of variables			gender difference	
variable	items	types of variables (scale) & categoreis	Types of statisitical test a)	p value
dependent variable	taste ability 2cat	ordinal scale: 0:no problem 1:cannot well or can hardly	chi	0.0069
ind_01	age10yrs	ordinal scale: 5: 50-59yrs 6: 60-69 7: 70-79 8: 80-89 9: 90-99	chi	0.1995
ind_02	total years staying at nursing home (years)	continuous scale	St	0.2009
ind_03	height (cm)	continuous scale	St	p<0.0001
ind_04	weight (kg)	continuous	St	p<0.0001
ind_05	BMI 3cat	ordinal scale: 1: <18,. 5 2: 18.5-<25.0 3:>=25.0	chi	p<0.0001
ind_06	total number of current diseases (0-15type) b)	descrete scale	St	0.6635
ind_07	LTCN: long term care need c) (=ADL)	ordinal scale: 0-5	chi	0.0306
ind_08	brushing times	ordinal scale: 0: never 1:once/day 2: tweice/day 3:>=3 times	chi	0.0045
ind_09	times of physical exercise	ordinal scale: 0: never 1:once/day 2: tweice/day 3:>=3 times	chi	0.3968
ind_10	smoking habit	ordinal scale: 0: never smoked 1: ex-smoker 2: current smoker 3: current heavy smoker (40+)	chi	p<0.0001
ind_11	alcohol habit	ordinal scale: 0: never drank 1: ex-drinker 2: current drinker 3: current heavy drinker (every day)	chi	p<0.0001
ind_12	sleeping	0: sound (deep) 1: sometimes cannot sleep soundly 2: seldom sleeps soundly	chi	0.5519
ind_13	bowel movement	ordinal scale: 0: no problem 1: often diarrrhea 2: often constipation	chi	0.2012
ind_14	smell ability	ordinal scale: 0: no problem 1: cannot well 2: can hardly	chi	0.6407
ind_15	total number of drugs consumption (0-23types) d)	discrere scale	St	0.0566
ind_16	Self-Reporting Questionaire 20 (SRQ20) e)	discrere scale	Wt	0.1954
ind_17	sigma of dry 1-6 symptons f)	discrere scale	St	0.8433
ind_18	total number of present teeth	discrere scale	Wt	0.2713
ind_19	pain of jaw joint	0: No 1: Yes		0.2506
ind_20	total number of caries g)	discrere scale	St	0.9066
ind_21	Eichner's Occlusal Supporting Zone (OSZ)	discrere scale	Wt	0.3299
ind_22	test ability for 1)-5) 1)sense of sweet h)	ordinal scale: Perception level of six categories defined by respective concentrations h)	chi	0.0903
ind_23	2)sense of salt h)		chi	0.0062
ind_24	3)sense of sour h)		chi	0.6848
ind_25	4)sense of bitter h)		chi	0.0892
ind_26	5) umami h)	ordinal scale: Feeling types for monosodium glutamate h) 0: felt bad 1: felt nothing 2: felt nice	chi	0.5696
ind_27	vol of saliva flow (cc) i)	continuous scale:	Wt	0.6189

Notes: a Types of statistical test: chi:chi-square test, St: Student's t-test for equal variances, Wt: Welch's t-test for unequal variance, Equality of variances was verified by F-test.

b Number of current sufering diseases are 15 such as heart disease, stroke ,hypertension,diabetes, Sjögren syndrom [6].

c The criteria for certification of long-term care need (LTCN) for the Elderly by Ministry of Health and Welfare, Japan [5].

d Total number of consumpted types of drugs are 23 such as drugs for cardiovascular diseases, hypertension, psychotropic (mental) diseases [6].

e The SRQ 20 (Self-reporting Qwuestionaire 20) is a 20 item self-report measure of mental health (WHO, 1994).

f Oral dryness was measured quantitatively by sum of six types of Visual Analog Scale (VAS) [6].

g Number of dental caries excluding teeth losing almost crowns by caries.

h The test consisted of aqueous solutions of sucrose, sodium chloride, sodium citrate, quinine hydrochloride dihydrate and monoso- dium glutamate [6].

i Total amount of flow saliva after chewing a cotton roll for two minutes.

before and after the nest-model (= deviance: difference between before -2LL and after it) reached the probability of the cut-off point (P_{in} = 0.14, P_{out} = 0.15). Consequently, final models with coefficients (Bs), standard errors (SEs), values of Wald, probabilities (Ps), Exp (Bs): odds ratios (ORs) with 95-percent confidence limits (95% CL) were obtained. The types of contrast for eighteen categorical data in b-LRAs were all “simple method”, and the first categories of each categorical variables were used as reference category, whereas nine numeric variables of independent variables were dealt as quantitative variables.

b-LRAs were performed by gender because many sub-risk factors of daily lifestyle such as smoking habit or alcohol consumption and physical status such as height, BMI, the number of present teeth are generally different between genders.

Multicolinearities [17] in the logistic regression solution were detected by examining the standard errors (SEs) for the coefficients (Bs). Independent variables with standard errors larger than 2.0 were dealt as variables with numerical problems, such as multicolinearity among the independent variables in the logistic regression models.

Multiplex collinearities were evaded by uniting categories with a little frequency to peripheral category in case of categorical variables, whereas all countable variables did not show multiplex coliniearities.

4. Taste sensitivity test and subjective taste ability (Physiological taste ability)

Taste sensitivity was assessed using the whole-mouth method [18] by two dentists on the basis of a manual for the taste sensitivity test prepared by investigators at Department of Dental Sociology, Kanagawa Dental University Graduate School of Dentistry. Five taste qualities (sweet, salty, sour, bitter and umami) were assessed with one compound per taste, and each compound was presented at five different concentrations, except for umami (one concentration). The test consisted of aqueous solutions of sucrose [0.1%, 0.3, 1, 3, 10 (w/w)], sodium chloride [0.03%, 0.1, 0.3, 1, 3(w/ w)], sodium citrate [0.003%, 0.01, 0.03, 0.1, 0.3 (w/w)], quinine hydrochloride dehydrate [(0.0001%, 0.003, 0.001, 0.003, 0.01 (w/w)] and mono-sodium glutamate [0, 0.05 Mol]. For each solution, subjects rinsed their mouth with the whole sample (5 mL) to evaluate the taste and then spit it out. Each subject was asked to identify whether a taste sensation was present and, if so, on the nature of the taste. They rinsed their mouth with distilled water before another taste was tested, but not before testing the next higher concentration of the same taste solution. A detection threshold, that is, concentration for absolute threshold of taste sensation, and whether or not the four kinds of tastes (sweet, salty, sour and bitter) were correctly identified were recorded.

5. Other independent variables

Sex, age, ethnicity, the number of years in nursing homes, activities of daily living (ADL), frequency of exercise, bowel movements, smoking status, drinking status, the current number of chronic diseases, the number and types of medications used, the Self-Report Questionnaire, 20-item version: SRQ 20 [19,20], and subjective smell (olfactory) ability were obtained from a self-reporting questionnaire or resident’s records from the facilities. To evaluate ADL, we ranked subjects according to six levels of long-term care need (LTCN) [5], which is a target index drawn up in 1997 by the Ministry of Health and Welfare, Japan, based on the definition by WHO [21]. Subjects were classified by the described condition and required care. The number of different chronic diseases from among hypertension, cardiac disease, stroke, diabetes mellitus, respiratory disease (asthma, chronic bronchitis or pulmonary emphysema), rheumatoid arthritis, and cancer was recorded. The accuracy of self-reports on selected data of chronic diseases was shown to be adequate [22]. The number of different medications taken regularly, including prescription, non-prescription medications, over-the-counter medications and vitamins, was recorded. Medications that were used by at least 5% of the study subjects were selected for examining types of medication. These were medicines for hypertension (37.2%), cardiovascular diseases (17.8%), diabetes (15.0%), asthma (8.4%) and mental disorders (8.0%), and vitamins (15.6%). Depression and anxiety in the participants were assessed using the SRQ 20, a screening tool for common mental disorders (CMD) designed by WHO for use in developing countries [19,20]. Respondents were asked 20 yes/no questions relating to the symptoms of depression and anxiety with a reference period of the previous 30 days. As the validation usually suggests a cut-off of 7/8 to separate probable non-cases from cases of CMD, this cut-off was used in this study [23]. The total number of present teeth and caries were dealt as discrete variables [15].

Eichner's classifications [24] were recorded by two dentists and classified into six levels (0, 0.5, 1, 2, 3, and 4), and dealt as discrete variable. Oral dryness was measured quantitatively by Saxon test [25], the sum of six types of Visual Analog Scale (VAS) [26]: i) Oral dryness at night or on awakening, ii) Oral dryness at other times of a day, iii)Oral dryness while eating , iv) Difficulty in swallowing foods , v)Amount of saliva in usual, everyday life, vi) Effect of oral dryness on daily life salivary flow was examined for 2 minutes by weighing a cotton roll.

6. Cross-tabulation

Finally, cross-tabulation tables by gender between taste ability and biggest magnitude factor detected by b-LRA were made, and chi-square test for independence and Mantel extension tests [27] were performed to evaluate overall trend adjusting for gender.

7. Ethical approval

This study was conducted in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki, and approved by the Ethical Review Committee of Sri Lanka Medical Association on 23rd March 2009. Written informed consent was obtained from all participants.

Results

Table 2 shows the number of participants by 10-year age groups by gender. The total number of participants was 403 males (mean age ± sd: 72.55 ± 9.27) and 612 females (71.57 ± 8.79). Gender difference of age is not significant by Student's t test.

Table 1 shows the types of statistical tests (chi: chi-square test, St: Student's t test, and Wt: Welch's t test) and significant level of gender differences of each independent variable are also shown in Table 1.

Dependent variable: category: 0 of taste ability two categories of female was 84.2%, while that of male was 77.4%. The difference of distribution of dependent variable between gender was significant ($p < 0.01$).

Independent variables: Height ($p < 0.001$), weight ($p < 0.001$), smoking habit ($p < 0.001$) and alcohol habit ($p < 0.001$) in males were significantly higher than those in females. On the contrary, BMI 3cat belonging to normal or overweight categories as 2 or 3 ($p < 0.001$), favorite brushing times over two times per day ($p < 0.01$), high sensitive sense of taste for salt ($p < 0.01$) and higher activities of daily living: ADL measured by LTCN less than level 2 ($p < 0.05$) in female were significantly higher than those in males. Gender differences of other 19 independent variables (Ind_01, 02, 06, 09, 12 - 22 and 24 - 27) were not significant.

Table 3 shows final b-LRA models by gender. In males, age, LTCN, sleeping, bowel condition, smell ability, and SRQ 20 remained in the final model (Negelkerke R^2 = 0.3578, percentage of correct discrimination by the final model was 77.4%). In females, height, weight, BMI 3, disease15, brushing times, smoking habit, alcohol habit, smell ability, SRQ 20, the number of present teeth, pain of jaw, and taste ability for salt remained in the final model (Negelkerke R^2 = 0.3293, percentage of correct discrimination by the final model was 84.2%). Significant odds ratio (OR) and 95% confidence limits (CL) of each variable in both models are as follows:

Male: LTCN: level 4 (OR: 3.5, CL: 1.32 - 9.65), level 5 (OR: 14.01, CL: 1.03,190.83), sleeping (cannot sleep soundly (OR: 3.82, CL: 1.86 - 7.83), seldom sleeps soundly (2.77, 1.20 - 5.91), bowel condition (often constipation(OR: 0.42,CL:0.21 - 0.86), smell ability (cannot well (OR: 8.69, CL: 4.34-17.39), can hardly (OR: 10.37,CL: 1.00 - 107.41)), SRQ20 (OR: 1.19, CL1.04 - 1.36)

Female: height (OR: 0.94, CL: 0.89 - 0.99), weight (OR: 1.07, CL: 1.00 - 1.14), BMI 3 cat (BMI > = 18.5 – BMI < 25.0: OR: 0.34, CL: 0.14 - 0.83), BMI > = 25.0: OR: p < 0.05, CL: 0.02 - 0.79)), brushing times (twice or more times/day OR: 0.37, CL: 0.17 - 0.79), smell ability (cannot well (OR: 9.40, CL: 5.44 - 16.25), can hardly (OR: 41.03, CL: 3.45 - 487.52), SRQ 20 (OR: 1.16, CL: 1.06 - 1.28).

The relationship between the total number of present teeth and the reduction of taste ability was not statistically significant, but showed almost significant tendency (p = 0.09).

However, there was no significant relationship between physiological tests of taste abilities and subjective taste ability although taste sensitivity to sweet taste remained in the female model, but not significant (p = 0.0769). Contrary to the authors' expectations, objective taste sensitivities and subjective taste sensitivity was only slightly related. This result suggested that recognition of the objective taste was greatly different from subjective taste.

Table 4 shows common independent variables, smell ability and SRQ 20, between two gender models. The cross-tabulation table between taste ability 2cat and smell ability 2 cat (the biggest magnitude factor) and the results of chi-square test for independence and Mantel Extension test

Table 2. Participants by age groups, by gender - Residents at 25 nursing homes in Sri Lanka -

age groups	gender: male	gender: female	total
50-59yr	31	55	86
60-69	121	183	304
70-79	145	249	394
80-89	93	113	206
90-99	13	12	25
total	403	612	1,015
mean	72.55	71.57	71.96
sd	9.27	8.79	8.98
maximum	96	94	96
minimum	51	50	51

were shown in Table 4. Both Chi-square tests for male and female showed high significant ($p < 0.001$), and Mantel extension test to evaluate overall trend between gender also showed high significant ($p < 0.001$).

Discussion

1. Participants

Nursing home residents were selected as subjects of this study because similarities of foods intake would contribute to the adjustment of confounding factors disturbing the identification of risk factors for the reduction of taste ability.

2. Gender differences

Gender (sex) differences can be evaluated by the statistical method that gender is dealt as a dummy variable (such as male: 1, female: 2) in a b-LRA model [16]. However, a definition of gender differences has polysemous meanings as biological, psychological and social [28,29]. Therefore, there is a strong likelihood that gender differences depends more or less on other significant variables which have inherent (such as height) or potential (such as smoking habit) gender differences in multiple variable model (MVM) such as b-LRA changeable by other arbitrary independent variables in respective MVMs. Thus, b-LRA was performed by gender in this study.

3. Common risk factors between genders

Only smell ability and SRQ 20 [19] were common significant factors in both genders (Table 3). Results indicated that the reduction of taste ability was 1.2 times more likely to occur in both genders when SRQ 20 had high score compared with when it is low. Depression and anxiety are not included in the classification done by Schiffman SS [2] as five types of disease/condition causing taste and smell problems. However, baseline measurements revealed significant group differences in taste of sucrose and bitter by F test with the mild subclinical anxiety group providing higher ratings than the no anxiety group, but differences were not found for sour and umami [30]. Thresholds for sweet and salty tastes were modulated during stressful conditions. It also demonstrated a relationship between taste perception and baseline anxiety levels of healthy individuals, which might be important to understand the appetite alterations in individuals under stressful conditions [31].

Problems with taste and smell ability are not the first concern of most health-care professionals in most disease states because of non-life-threatening symptoms [32]. However, taste and smell contribute to the long-term energy deficit by dictating poor quality and quantity of nutrient intake, and the detrimental effect not only on patients but also the carer in case of cancer or liver disease [32]. A strong positive relationship between taste ability and smell ability shown in Table 3 and Table 4 is supported by Miwa T, et al. study [33]. In addition, the comparison between impaired group suffering olfactory loss and improved group showed the difference in “Altered taste of food” (impaired group: about 60%, improved group: about 35%) [34]. The strong relationship between taste ability and smell ability are extremely difficult to explain reasonably, therefore following three hypothetical explanations are necessary to be confirmed in future studies.

a) Subjective taste ability is dynamic perception based on individual change, while physiologic tests of taste ability are not dynamic or cross-sectional.

b) Participants might be likely to often confuse the reduction of smell ability with that of taste ability.

c) If integration of subjective taste ability and smell ability creates sense of flavor, subjective taste ability might not be in accord with physiological taste ability.

NIH (National Institute of Health, US) explains

Table 3. Factors influencing reduction of subjective sense of taste
- binary logisitic regression model [a] with backword elimination [b] -

variables in the Equation							odds ratio		
reference category for odds ratio	categoreis / *numeric*	B:coefficient	se	Wald	df	p value	Exp(B)	95% C.I.for Exp(B)	
							Exp(kB)[e]	lower	upper
<male> [c]									
1) age10yrs: ten-year age group				9.9312	4	0.0416			
5:50-59yr	6: 60-69 yr	1.3966	0.7140	3.8260	1	0.0505	4.0414	0.9972	16.3793
	7: 70-79	0.7458	0.7114	1.0990	1	0.2945	2.1082	0.5228	8.5007
	8: 80-89	0.2538	0.7627	0.1108	1	0.7393	1.2890	0.2891	5.7469
	9: 90-99	1.5431	0.9643	2.5605	1	0.1096	4.6791	0.7068	30.9754
2) LTCN: long term care need				9.3637	5	0.0954			
LCTN level=0	1: level 1	0.2821	0.3967	0.5057	1	0.4770	1.3259	0.6093	2.8850
	2: level 2	0.4911	0.5307	0.8564	1	0.3548	1.6342	0.5775	4.6243
	3: level 3	0.4565	0.5111	0.7979	1	0.3717	1.5786	0.5797	4.2985
	4: level 4	1.2709	0.5083	6.2519	1	0.0124	3.5642	1.3161	9.6521
	5: level 5	2.6400	1.3324	3.9261	1	0.0475	14.0131	1.0290	190.8294
3) excersise				3.3806	2	0.1845			
0: never	1: once/day	-0.4525	0.3223	1.9710	1	0.1603	0.6360	0.3381	1.1963
	2: tweice/day +3: >=3 times	-1.4428	1.0950	1.7361	1	0.1876	0.2363	0.0276	2.0205
4) sleeping				13.8086	2	0.0010			
0: sleep soundly (deep)	1: cannont sleep soundly	1.3403	0.3661	13.4065	1	0.0003	3.8203	1.8643	7.8287
	2: seldom sleeps soundly	1.0188	0.3863	6.9553	1	0.0084	2.7699	1.2991	5.9059
5) bowel condition				7.6390	2	0.0219			
0: no problem	1: often diarrrhea	0.3054	0.3980	0.5890	1	0.4428	1.3572	0.6221	2.9608
	2: often constipation	-0.8568	0.3617	5.6117	1	0.0178	0.4245	0.2089	0.8625
6) smell ability common in gender				39.6059	2	p<0.0001			
0: no problem	1: cannot well	2.1618	0.3542	37.2517	1	p<0.0001	8.6869	4.3388	17.3923
	2: can hardly	2.3397	1.1923	3.8506	1	0.0497	10.3785	1.0028	107.4139
7) SRQ20: self-report questionnaire 20	*numeric (discrete)*	0.1707	0.0688	6.1540	1	0.0131	1.1861	1.0365	1.3573
Constant		-3.2455	0.4798	45.7483	1	p<0.0001	0.0390		

variables in the Equation							odds ratio		
reference category for odds ratio	categoreis / *numeric*	B:coefficient	se	Wald	df	p value	Exp(B)	95% C.I.for Exp(B)	
							Exp(kB)[e)]	lower	upper
<female> [d)]									
1) height (cm)	*numeric (continuous)*	-0.0578	0.0249	5.3899	1	0.0203	0.9439	0.8989	0.9910
2) weight (kg)	*numeric (continuous)*	0.0673	0.0338	3.9752	1	0.0462	1.0696	1.0011	1.1428
3) BMI 3cat				6.1007	2	0.0473			
BMI<18.5	BMI>=18.5 - <25.0	-1.0665	0.4475	5.6792	1	0.0172	0.3442	0.1432	0.8275
	BMI>=25.0	-2.1544	0.9781	4.8519	1	0.0276	0.1160	0.0171	0.7887
4) disease15	*numeric (discrete)*	0.1944	0.1173	2.7483	1	0.0974	1.2146	0.9652	1.5285
5) brushing				6.8142	2	0.0331			
brushing: 0 times/day	once/day	-0.5632	0.3774	2.2272	1	0.1356	0.5694	0.2717	1.1930
	twice or more times /day	-1.0053	0.3916	6.5914	1	0.0102	0.3659	0.1699	0.7883
6) smoking never smoked	ex, current,current heavy smoker	2.5778	1.7603	2.1446	1	0.1431	13.1687	0.4180	414.8452
7) alcohol never drank	ex, current,current heavy drinker	-2.2715	1.7262	1.7317	1	0.1882	0.1032	0.0035	3.0396
8) smell ability				69.4045	2	p<0.0001			
no problem	cannot well	2.2409	0.2793	64.3691	1	p<0.0001	9.4016	5.4382	16.2535
	can hardly	3.7144	1.2627	8.6528	1	0.0033	41.0347	3.4539	487.5207
9) SRQ20	*numeric (discrete)*	0.1514	0.0481	9.8927	1	0.0017	1.1634	1.0587	1.2785
10) presentT	*numeric (discrete)*	-0.0316	0.0188	2.8113	1	0.0936	0.9689	0.9338	1.0053
11) pain of jaw joint:no	Pain: yes	-0.5782	0.3422	2.8552	1	0.0911	0.5609	0.2868	1.0969
12) taste ability for sweet				9.9429	5	0.0769			
ability level 1: highest ability	ability higher	-0.2252	1.4131	0.0254	1	0.8734	0.7983	0.0500	12.7347
	high	-0.3740	1.2936	0.0836	1	0.7725	0.6880	0.0545	8.6826
	moderate	-0.1625	1.2873	0.0159	1	0.8995	0.8500	0.0682	10.5973
	low	-0.7295	1.3182	0.3062	1	0.5800	0.4822	0.0364	6.3862
	lower or non	0.8676	1.3351	0.4223	1	0.5158	2.3812	0.1739	32.5997
constant		4.0767	3.1380	1.6878	1	0.1939	58.9527		

Notes: [a] Dependent variable: sense of taste 2 cat
[b] Conditions: backward elimination, likelihood method , Pin = 0.14, Pout = 0.15
[c] Validity of male model: Binary logistic regression model was converged in 21 steps (-2 log likelihood = 322.662, Negelkerke R^2 = 0.3578). Percentage of correct discrimination by the final model was 77.4%.
[d] Validity of female model: Binary logistic regression model was converged in 16 steps (-2 log likelihood = 404.651, Negelkerke R^2 = 0.3293). Percentage of correct discrimination by the final model was 84.2%.
[e] Incremental odds ratio corresponding to the reasonable change of k units in valiable can be obtained by exp (kB).

that smell and taste are closely linked in the brain, but are actually distinct sensory systems. The loss of smell is much more common than the loss of taste, and many people mistakenly believe they have a problem with taste, when they are really experiencing a problem with their sense of smell [35].

4. Common non- risk factors (p > 0.15) between genders

According to the relevant study in Pakistan [36], zinc deficiency is an emerging health problem as about 20.6% of children are found in the levels of zinc below 60 μg/dL. Signs and symptoms caused by zinc deficiency are poor appetite, weight loss, and poor growth in childhood, delayed healing of wounds, taste abnormalities, and mental lethargy.

Zinc deficiency is one of the ten biggest factors contributing to the burden of diseases in developing countries. Populations in South Asia, South East Asia, and sub-Saharan Africa are at the greatest risk of zinc deficiency. On the other hand, according to an official report [37] relating to nutritional deficiencies in Sri Lanka, while zinc deficiency has been identified as a significant problem of public health in other regions of the world, there are currently no available data on the extent or severity of zinc deficiency in Sri Lanka. Therefore, there is no evidence that the participants of this study lived under zinc deficiency or not.

If total years staying at a nursing home significantly have related to the reduction of taste ability, one of main causes might be zinc deficiency due to low-zinc feeding services at each nursing home. However, such tendency was not demonstrated in this study in both genders.

5. Different risk factors by genders

Age-related factors and smoking are important determinants of impaired sensory functions (smell and taste) [34]. In this study, age groups indicated almost significant tendency in one age group of male case, but not significant in other age groups and all age groups in female.

Inflammatory bowel disease (such as Crohn's disease and ulcerative colitis) patients exhibited significant reductions in the olfactory and gustatory functions [38].

Variable of suffering diseases under ‘General status’ in the Cause and Effect Diagram was evaluated using the total number of current diseases from fifteen diseases. It was not statistically significant at 5% level, but very close to the significant level (p = 0.0974) in female Model. Schiffman SS [2] classified five types of disease/condition causing taste and smell problems as nervous status (such as Bell palsy, head trauma), nutritional status (such as cancer,

Table 4. Relationship between sense of taste and sense of smell

sense of taste \ sense of smell		reduction(-)	reduction(+)	statistical significant test
male	reduction(-)	285(91.3%)	27(8.7%)	$p<0.001^{a)}$
	reduction(+)	54(59.3%)	37(40.7%)	
female	reduction(-)	462(89.7%)	53(10.3%)	$p<0.001^{a)}$
	reduction(+)	46(47.4%)	51(52.6%)	
total				$p<0.001^{b)}$

Notes: [a] Chi-square test for independence
[b] Mantel Haenzel test: Overall trend betweem sense of taste and sense of smell adjusting gender

Zinc deficiency), endocrine status (such as diabetes mellitus, Cushing syndrome), local status (such as sinusitis, Sjögren's syndrome) and viral infections (such as acute viral hepatitis, influenza like infections). Percentages of participants with one or more diseases are nearly 95% in both genders; however, specific diseases classified by Schiffman SS (2) could not be identified in this study. Therefore, the total number of current diseases out of 15 basic diseases, standing on the premise that each disease has a possibility to affect the taste ability more or less, was dealt as one of the independent variables. Schiffman SS (2) also classified 23 types of drug for causing taste and smell problems. Percentages of participants with one or more diseases are 65% in male and 74% in female; however, specific drugs classified by Schiffman SS (2) could not be identified in this study. Therefore, the total number of drug consumptions out of 23 basic drugs, standing on the premise that each drug has a possibility to affect the taste ability more or less, was dealt as one of the independent variables same as the number of diseases mentioned above.

Considering the number of participants using some types of drug, there was no relationship between drug consumption and the reduction of taste ability. This could be because very sick participants taking many drugs were not dealt in this study.

Height and weight remained in the female final model, but interpretation of the meaning was impossible. However, taste ability seemed to be sensitive in higher BMI category. As mentioned above, taste and smell contribute to the long-term energy deficit by dictating poor quality and quantity of nutrient intake [20]. Percentage of residents at 25 nursing homes with low BMI as less than 18.5 are about 30% in both genders. Therefore, improving the reduction of taste and smell ability will contribute to the prevention of weight loss for the elderly.

LTCN developed by the Ministry of Health, Labour and Welfare, Japan, is one of the index for Activities of Daily Living (ADL) and focusing on the measurement of necessary care for the elderly with low ADL. LTCN over level 4 indicated an obstructive factor (odds ratios 1.3 - 3.6) for taste ability in male. Odds ratio of LTCN, 3.3 - 5.0, in our preliminary trial [5] in 2006 though gender difference was dealt as one independent factor. A relationship between LTCN and taste ability has not seemed to be discussed directly except our two previous studies [5,6].

Sweet taste perception in healthy young men was not altered after acute sleep deprivation [39]. Other relevant studies discussing the relationship between sleeping deprivation and the reduction of taste ability were not detected except our two previous studies [5,6].

Tabaco is expensive for people in general in Sri Lanka, and smoking and alcohol consumption at nursing homes are generally regulated quantitatively. Thus, smoking and alcohol habit did not remain in the male BLR model or were not significant in the female model.

The result (Table 3) significantly ($p < 0.05$) indicated that tooth brushing habit (over twice times/day) contributed to the maintenance of high taste ability in female. The taste sensation improved after 2 weeks of tongue cleaning, especially with a scraper (significant improvements for quinine and sodium chloride) [40]. Oral care for bedridden elderly people is one of the most necessary forms of care not only for prevention of oral infection or aspiration pneumonia, but also in order to savor the taste of food and to recover and maintain mental vitality through the improvement in oral function [41] .

Tooth, tongue or denture brushing habit is changeable and easily acceptable, thus eventually will contribute to the improvement of taste ability. Therefore this habit should be recommended at elderly nursing homes.

Before the study, the authors assumed that the subjective taste sensitivities would have a strong relationship with the threshold of the objective sense of taste, at least related to a threshold of one of five tastes: sweet, or salt or sour or bitter or umami. Contrary to the expectation, the result of this investigation suggested that the perception of subjective sense of taste was different from the objective sense of taste.

Conclusions

The results of this investigation strongly indicated that the perception of subjective sense of taste was different from the objective sense of taste.

Smell ability and SRQ 20 were common significant risk factors for the reducing subjective taste ability in both genders. Especially, smell ability was closely linked to taste ability. Existence of comprehensive perception as “flavor” composed of taste and smell ability was illustrated. Significant gender differences regarding the risk factors were observed in such as LTCN, sleeping, bowel condition in males, height, weight, BMI 3 categories, the total number of current diseases, and brushing habit in females. Other variables such as age, total years staying at a nursing home, five types of physiological taste abilities, and oral dryness were not significant in both genders.

Epidemiological studies such as cohort or intervention studies focusing a relationship between subjective taste ability and sense of smell or a link between daily zinc intake and sense of taste are necessary to identify more accurate risk factors and changeable risk factors for the dysgeusia in order to improve nutritional intake among the middle aged and elderly in Sri Lanka.

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