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Oral health behaviours and oral health-related dietary behaviours: The interrelationship and determinants by latent class analysis

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Objective: This study aimed to investigate the level of oral health behaviours (OHB) and oral health-related dietary behaviours (OHD-B) and to find out their relationship and their determinants among a relatively large sample of university students. ***Research design and participants***: In a cross-sectional study, 535 Iranian university students were selected in order to investigate their OHB and OHD-B through a self-administrated questionnaire. ***Main outcome measures***: Tooth brushing, flossing, use of fluoride toothpaste, and sugary snacking collected data on OHB. Consumption frequency of 16 common cariogenic and non-cariogenic foodstuffs was used for evaluation of OHD-B. Latent class analysis (LCA) and latent class regression (LCR) were applied to identify classes of OHB and OHD-B and their potential determinants, respectively. ANOVA, Chi-square and Spearman's correlation were used. ***Results***: In total, 49.7% and 53.2% of participants had good OHB and OHD-B, respectively. The results of LCR indicated that female gender (OR: 8.22, 95% CI: 3.42-19.72), higher age (OR: 1.39, 95% CI: 1.04-1.85), doctorate level (OR: 6.99, 95% CI: 2.22-21.98), and being single (OR: 3.54, 95% CI: 1.36-9.19) were related to good OHB. Furthermore, LCR analysis showed that students who lived with their families had greater chance for having good OHD-B (OR: 3.01, 95% CI: 2.00-4.53). Students with good OHD-B reported brushing and flossing their teeth more frequently than those with poor OHD-B (P<0.05). ***Conclusions***: The shortage of favourable oral health behaviours among university students highlights the importance of planning oral health programs to improve their oral health, especially their dietary behaviours.

Key words: *Oral health, health behaviours, diet, sociodemographic determinants*

Introduction

Dental caries continues its increasing trend in many developing countries, while its prevalence has decreased within developed countries (Frencken *et al*., 2017). Beside other health-related factors, this can be related to specific oral health behaviors (OHB), such as tooth brushing with fluoride toothpaste, dental flossing and diet. The convergence towards less healthy diets, particularly in developing countries, has raised the global health challenge of nutrition transition (Imamura *et al*., 2015). A shift from a traditional dietary pattern (including grains and vegetables) toward a modern one (which is high in saturated fat, sugar, and refined foods and low in fiber) exemplifies this nutrition transition. Nutrition transition leads to higher intake of high-calorie sources, especially among the younger population (Ghassemi *et al*., 2002), contributing to the increasing trend of dental caries (Bayat-Movahed *et al*., 2011).

When providing oral health promotion during routine oral health instruction in dental clinics and in the daily oral health behaviors of individuals, more emphasis is focused on oral self-care behaviors, such as tooth brushing, while dietary aspects of OHB can be overlooked (Franki *et al*., 2014). Moreover, oral health studies often focus on measuring tooth brushing and flossing as indicators of OHB, whereas the effects of dietary habits on dental caries have not been extensively evaluated. Multiple environmental, social and personal factors such as socialization, cultural norms, socio-demographic disparities, individuals' food preferences, and dietary knowledge are responsible for differences in dietary behaviors (Hardcastle and Blake, 2016).

To the best of the researchers' knowledge, no study has been conducted on the interaction of the components of general oral health behaviors (OHB) and oral health-related dietary behaviors (OHD-B) and their determinants. Therefore, the purpose of the present study was to investigate the level of OHB and OHD-B and identify their relationship and determinants among a relatively large sample of university students in Isfahan, Iran.

An advanced statistical method, latent class analysis (LCA), was applied to determine OHB and OHD-B because these variables were considered as latent constructs that could not be directly observed (Vermunt and Magidson, 2003). Participants were classified based on OHB and OHD-B indicators using LCA. Moreover, latent class regression (LCR) was used to investigate the potential determinants of OHB and OHD-B.

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Method

The study was initiated by selecting a representative sample of students from University of Isfahan from four Faculties (Literature and Humanities, Administrative and Economics, Engineering, and Basic Sciences) and Isfahan University of Medical Sciences including five Faculties (Medicine, Dentistry, Nursing and Midwifery, Health, Nutrition and Nutritional Sciences). Sample selection was based on multistage cluster sampling where the sample size in each faculty was proportional to its population. The participants were randomly selected from Bachelor (in their second year and above), Master, Medical Doctorate, and PhD students. One of the researchers (Z.E) explained the purpose of the research to the participants who were selected from different classes, then distributed the self-administrated questionnaires. Over the 8-week data collection period, 535 students agreed to participate (322 from the University of Isfahan and 213 from the Isfahan University of Medical Sciences), making the overall response rate 89%. The Ethics Committee of Isfahan University of Medical Sciences approved the study protocol.

Based on previous studies (Moynihan, 2002; Saied-Moallemi *et al*., 2007), a self-administrated questionnaire was developed for this study. The socio-demographic section gathered information on gender, age, marital status, educational level, and place of residence. OHB was evaluated based on four questions on tooth brushing frequency, flossing, use of fluoride toothpaste, and sugary snacking. For assessment of oral health-related dietary knowledge (OHD-K), perceptions of the cariogenicity of 24 common cariogenic (soft drink, industrial fruit juice, honey, etc.) and non-cariogenic (nuts, fresh vegetables, cheese, etc.) foodstuffs were ascertained on a three-point scale as 'cariogenic', 'non- cariogenic' and 'do not know'. OHD-B was based on the frequency of consumption of 16 foodstuffs on a seven-point scale as 'never or seldom', '1-3 times per month', '1-3 times per week', '5 or more times per week', '1-2 times per day', '3-4 times per day', '5 or more times per day' (Stegeman and Davis, 2014). The content and face validity of the questionnaire and its subscales were confirmed by a panel of experts. A pilot study with 20 participants was used to evaluate the internal consistency using Cronbach's alpha. The minimum acceptable Cronbach's alpha level of 0.7 was exceeded by all sections of the questionnaire.

Continuous and categorical data were expressed as means and standard deviations (SD) and frequencies. Analysis of variance (ANOVA), Chi-square test and Spearman's correlation were used where appropriate, to examine differences in general characteristics between classes of OHB and OHD-B.

Oral health-related dietary knowledge (OHD-K) responses were dichotomized as correct and incorrect (Moynihan, 2002). 'Do not know' was treated as an incorrect answer. Then, the number of correct answers was summed for each participant (described as mean and SD) for comparison between groups.

The level of OHB and OHD-B was analysed with latent class analysis (LCA) (Vermunt and Magidson, 2003) as they were considered as latent variables that could not be evaluated directly. LCA allowed us to examine the pattern of relations among a set of observed indicators form OHB and OHD-B domains, and to classify similar individuals into latent classes. This grouped participants who were highly similar in terms of OHB and OHD-B indicators within each latent class. Latent class regression (LCR) was used to determine the potential predictors of OHB and OHD-B. Latent class membership (i.e., levels of OHB and OHD-B), as a multinomial dependent variable, was predicted by a set of predictors (including gender, age, marital status, level of education, place of residency, and OHD-K), similar to the multinomial logistic regression. In model fitting, a simple LCA model, with a different number of classes (2–5 classes), was firstly fitted to find the optimal number of classes based on statistical fitting criteria of lower values of the Akaike Information Criterion and Bayesian Information Criterion (AIC and BIC respectively) and the results' interpretability. Accordingly, a model with three latent classes for OHB and two latent classes for OHD-B were achieved; and predictors were entered into the LCR model. All analyses were performed using 'R' (Version 3.3.2), an open source and comprehensive statistical package.

Results

There were 535 participants (381 (72.6%) female) with a mean age of 23.6 (SD = 4) years. Most participants were single (76.5%).

We estimated a series of LCA models to determine the number of latent classes (2-5 latent classes) for OHB and evaluated them with model fit criteria including AIC and BIC. All model fit criteria, as well as the interpretability of extracted classes strongly suggested the LCA model with three latent classes based on different questions of OHB. The lowest values for AIC and BIC were achieved for the 3 class solution (AIC: 2-Class = 195172.9, 3-Class = 182650.6, 4-Class = 213177.4, and 5-Class = 203177.4; BIC for 2-5 classes: 195509.5, 183201.4, 213942.4, and 204845.6, respectively).

The weighted percentages for the three constructed classes of OHB were 49.7% (n = 266) for class 1, 42.6% (n = 228) and 7.6% (n = 41). Figure 1 displays the cluster-specific estimated probabilities of oral health behaviors for the three-cluster model. Class 1 (good OHB) had higher frequencies of tooth brushing, dental flossing, use of fluoride toothpaste, and sugary snacking. Class 2 (moderate OHB) had a lower frequencies for sugary snacking and moderate frequencies for other oral health behaviors. Class 3 (poor OHB) had moderate frequency for sugary snacking and lower frequencies of other oral health behaviors.

The good OHB class contained more female students than males ($P<0.001$). Such students tended to be older, at a higher level of education and more likely to live with their family ($P<0.05$). In LCR analysis, females (OR: 8.22, 95% CI: 3.42-19.72), older (OR: 1.39, 95% CI: 1.04-1.85), Doctorate (OR: 6.99, 95% CI: 2.22-21.98) and single-students (OR: 3.54, 95% CI: 1.36-9.19) were more likely to have good OHB than the male, younger, Bachelor or Masters, and married participants (Table 1).

The mean OHD-K score of students was 16.51 (SD = 3.8) out of 24. Students with better knowledge about the cariogenicity of different foodstuffs reported better OHB ($P<0.001$) and were more likely to be in the good OHB class (OR: 1.11, 95% CI: 1.01-1.23) (Table 1).

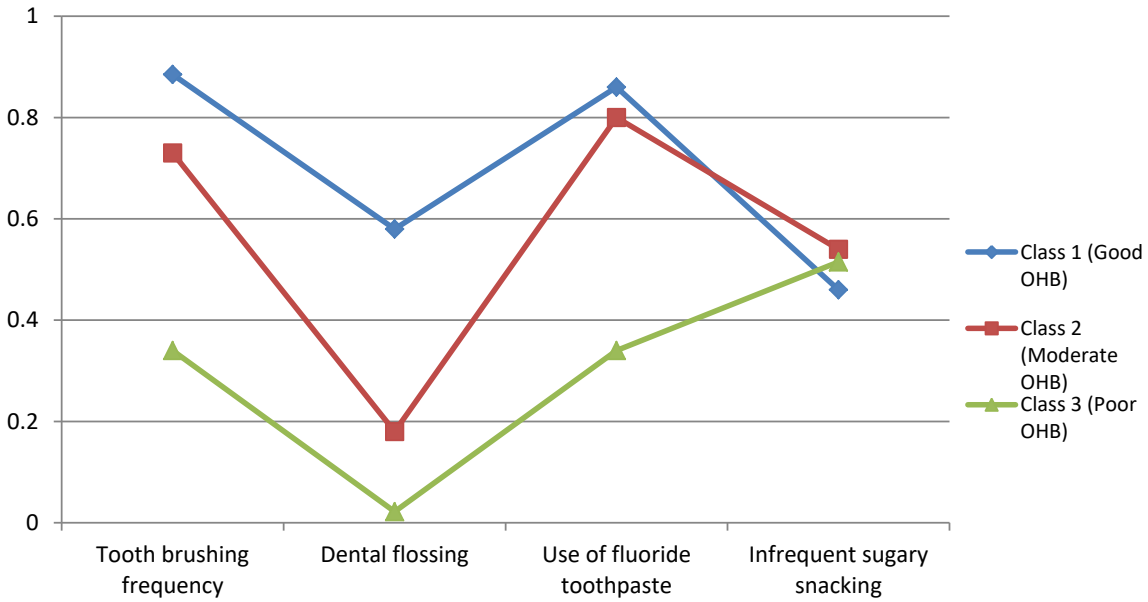

Figure 1: Cluster-specific probabilities of oral health behavior (OHB) for the three-cluster model (N= 535)

Table 1. Multivariable-adjusted latent class regression models for predictors of good and moderate oral health behaviours

	Good OHB[3]		*Moderate OHB*[2]	
Background factors	*OR*	*95%CI*	*OR*	*95%CI*
Age (Mean)	1.390	1.045-1.850	1.414	1.064-1.878
Gender				
Male (ref)[1]				
Female	8.216	3.424-19.717	4.044	1.738-9.411
Marital status				
Married (ref) [1]				
Single	3.538	1.362-9.192	1.651	0.655-4.160
Education				
B.S. (ref) [1]				
M.S	2.629	0.480-14.400	1.129	0.207-6.147
Doctorate	6.987	2.221-21.975	1.230	0.387-3.905
Place of residence				
With family (ref) [1]				
Private home	0.906	0.177-4.627	1.538	0.308-7.673
Dormitory	1.361	0.544-3.405	3.258	1. 341-7.918
OHD-K (Mean)	1.115	1.011-1.229	1.064	0.973-1.164

[1]ref: reference category
[2]Poor OHB was considered as reference category

The LCA fit measures indicated that a two-cluster solution was the most appropriate for OHD-B. Class 1 (Good OHD-B) represented a lower frequency of consumption of cariogenic foods and higher frequencies for consumption of non-cariogenic foods, which comprised 53.2% (n=285) of participants. Class 2 (Poor OHD-B) comprised participants with higher frequencies of consumption of cariogenic foods and a lower frequency of consumption of non-cariogenic foods (46.8%, n=259) (Figure 2).

Students in the good OHD-B class were more likely to have higher levels of education, to live with their family, and and to have better OHD-K (P<0.05). Later, LCR analysis indicated that students who lived with their families were more likely to have good OHD-B OR: 3.01, 95% CI: 2.00-4.53) than those living in dormitories. In addition, more Doctorate students had good OHD-B (OR: 1.57, 95% CI: 0.99-2.50). No association was found between good OHD-B and OHD-K (Table 2).

Analyses of the relationship between clusters of OHB and OHD-B showed more students with good OHD-B had good OHB (58.1%), while 35.8% of them were in the moderate, and 6.2% were in the poor OHB classes (P<0.001). Associations between OHD-B classes and components of OHB are illustrated in Table 3. Students in the good OHD-B class brushed and flossed their teeth more frequently than those in poor OHD-B class (P<0.05). Although not predicted, students in the good OHD-B class reported having sugary snacking between meals more than their counterparts with poor OHD-B (P<0.001). As illustrated in Table 3, participants in the good OHD-B class assessed their oral health status better, and their dental treatment needs as lower than their counterparts in the poor OHD-B class (P<0.05).

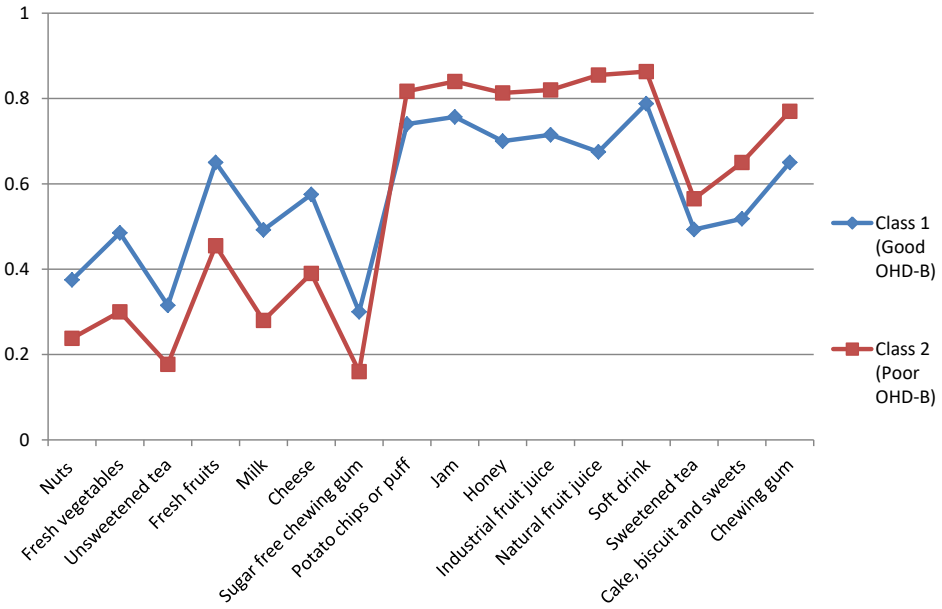

Figure 2: Cluster-specific probabilities of oral health-related dietary behaviours (OHD-B) for the two-cluster model (N= 535)

Table 2. Multivariable-adjusted latent class regression models for predictors of oral health related dietary behaviours

Background factors	*Good OHD-B*[2]	
	OR	*95%CI*
Gender		
Male	1.113	0.736-1.686
Female (ref) [1]		
Age	0.935	0.856-1.020
Marital status		
Single (ref) [1]		
Married	1.269	0.783-2.057
Education		
B.S. (ref) [1]		
M.S	1.169	0.631-2.165
Doctorate	1.573	0.988-2.504
Place of residence		
With family	3.010	2.001-4.526
Private home	1.497	0.755-2.964
Dormitory (ref) [1]		
OHD-K	1.019	0.964-1.077

[1]ref: reference category
[2]Poor OHD-B was considered as reference category

Discussion

These data provide a comprehensive view of the interaction of general and diet related oral health behaviors, using a sophisticated statistical method, i.e. LCA, to indirectly evaluate these contexts based on a set of relevant indicators. About half of the university students had good OHB and OHD-B. Good OHB was more frequent among female, older, Doctorate, and single students. Good OHD-B was only observed among those students living with their family. Students with good OHD-B had better OHB components of tooth brushing and dental flossing than those with poor OHD-B.

Only fifty percent of the university students had good OHB. Previous studies have observed inadequate oral self-care behaviors among Iranian university students, including dental students (Neamatollahi and Ebrahimi, 2010). A large study conducted in 26 countries explored oral self-care behaviors among university students across different cultures in Africa, Asia and America (Peltzer and Pengpid, 2014). Surprisingly, university students, who comprise the educated class of society, often demonstrate unfavorable oral self-care behaviors in comparison with the general population.

More female students reported to good OHB compared to male students. Similar findings were observed among university students in other countries (Al-Wahadni *et al*., 2004; Peltzer and Pengpid, 2014). Women may pay more attention and find more time for their oral health (Peltzer and Pengpid, 2014; Thapa *et al*., 2016).

Contrary to the findings of Peltzer and Pengpid (2014), these data provide evidence that older students have better oral health behaviors. In line with the results of other studies (Al-Wahadni *et al*., 2004; Peltzer and Pengpid, 2014), our findings indicate that higher-educated students had better OHB. Both older age and a higher level of education may improve oral health behaviors by affecting oral health attitudes (Al-Wahadni *et al*., 2004).

Similarly, better OHB was observed among single than married students. This finding was in agreement with a study in Nepal (Thapa *et al*., 2016). It might be that family responsibilities, causing more stress, and occupying more time among married students may reduce attention on oral self-care behaviors.

Most students had good OHD-B. Another study indicated unsatisfactory dietary habits among Iranian university students (Neamatollahi and Ebrahimi, 2010). The nutritional transition in Iranian young adults, which leads to high intake of sweets, sugar-sweetened beverages, fast foods and refined grains may explain these findings (Ghassemi *et al*., 2002; Mohammadifard *et al*., 2012). In developed countries, a declining trend in consumption of sweetened beverages among young people and adults has been observed; benefitting from health promotion programs both in public health and medical sectors (Moynihan, 2002; Kankaanpää *et al*., 2014).

In the present study, students living with their families and those in Doctorate level education reported better diets; eating more fruits and vegetables and less sugary snacks.

Table 3. Distribution of participants' responses to indicators of oral health behaviours (OHB) and their self-assessed oral health status in two constructed classes of oral health related dietary behaviours (OHD-B)[1]

	Class 1 "Good OHD-B" (%)	*Class 2 "Poor OHD-B" (%)*	*P-value*[2]
Indicators of oral health behaviours:			
How often do you brush your teeth?			0.006
More than once a day	40.0	22.0	
Once a day	50.2	65.7	
Two or three times in a week	4.7	5.9	
Once a week	0.7	1.7	
Irregular or never	4.4	4.7	
How often do you usually floss your teeth?			0.002
More than once a day	12.8	7.6	
Once a day	23.4	15.3	
Two or three times in a week	12.8	15.3	
Once a week	11.7	11.4	
Irregular or never	39. 4	50.4	
Do you use fluoridated toothpaste while brushing?			0.664
Never	3.8	3.9	
Rarely	8.3	9.6	
Often	32.1	32.0	
Always	55.8	54.4	
How often do you usually eat a sugar containing snack or drink (like cake, biscuits and fruit juice) between your meals?			<0.001
Four to Five times in a day	17.7	9.54	
Three times in a day	17.7	12.53	
Twice a day	23.6	19.97	
Once a day	18.5	20.81	
Sometimes, not daily	18.5	30.11	
Rarely or never	4.1	7.03	
Self-assessed oral health status:			
How do you assess your oral health?			0.004
Very poor	1.5	6.8	
Poor	9.5	13.7	
Fair	31.4	20.1	
Good	44.2	20.1	
Very good	13.1	31.6	
Don't know	0.4	7.7	
How do you assess your dental treatment needs?			0.024
Very high	2.5	5.5	
High	18.5	20.4	
Moderate	32.4	37.0	
Low	28.0	23.4	
Very low	17.5	12.3	
Don't know	1.1	1.3	
Cluster size	53.2%	46.8%	

[1]Probability of endorsing item given latent class
[2]Chi-square test

These findings are in line with the findings from Iranian adults (Mohammadifard *et al*., 2012) and among university students in other countries (El Ansari *et al*, 2012). When university students leave their family home and live independently, their access to fresh fruits and vegetables and healthy eating habits may decline (El Ansari *et al*., 2012). On the other hand, higher educated students were more likely to follow good dietary habits (Mohammadifard *et al*., 2012).

Even though knowledge and attitudes feature highly in explaining human behavior in many behavioral theories, there is often a discrepancy between knowledge and practice, because environmental, social and personal factors influence human behavior (Saied-Moallemi *et al*., 2008). As shown in the present study, participants' OHD-B did not show a significant relationship with their OHD-K. Similar results suggest that nutritional knowledge is not the only factor that can impact eating behavior (Mirmiran *et al*., 2007).

On the other hand, students with better OHB had higher OHD-K. Their higher level of knowledge on the cariogenicity of foods may promote their favorable behaviors on tooth

brushing frequency and using fluoride toothpaste, but less so on healthy snacking. It may be that their greater knowledge of the cariogenicity of foodstuffs, was used to compensate for the harm of sugary snacking by more frequent tooth brushing. Nevertheless, social desirability bias should be considered in all self-reported health behavior surveys (Saied-Moallemi *et al*., 2007).

The detailed questions about diet used in this study may assess oral health-related dietary behaviors better than single questions about the frequency of sugary snacking between meals. A single question may fail to give a comprehensive view of an individual's diet and can overlook the consumption of healthy foods such as vegetables and fruits that may indirectly reduce sugary snacking.

Oral health-related dietary behaviors were associated with two general oral health behaviors: tooth brushing and flossing. University students with poor OHD-B brushed and flossed their teeth less frequently than those with good OHD-B. This means that two main risk factors for dental caries, i.e. inappropriate oral self-care and a cariogenic diet were clustered within these students. Interestingly, the students with poor OHD-B assessed themselves as having poor oral health status and with more perceived dental treatment need. This accumulation of poor oral health behaviors and status requires policy makers to consider all determinants of oral health, when planning oral health promotion programs (Moynihan, 2002). Much oral health education in dental settings does not include dietary advice, or, this advice may comprise a single statement with little interaction with patients (Franki *et al*., 2014). Dietary advice in dental practice should be specific to the individual, simple, concise and consistent with dietary guidance for general health (Moynihan, 2002).

Although this study benefited an advanced statistical analysis, its limitations should be considered while interpreting the results. Although the participants were selected from different science fields of the universities, they were not a representative sample of all young adults. Future studies are required with more participants of various ages and from non-academic environments. No dental examination was performed in this study. Assessing oral health status in future studies can be helpful. Although, self-assessed oral health status is recommended for epidemiological studies, for economic and organizational reasons (Tseveenjav *et al*., 2014).

Conclusion

As a highly educated class of society, the dental status and dietary behaviours among university students might be expected to be healthier. These findings highlight the importance of planning oral health promotion programs to improve the oral health of university students especially their dietary behaviours. General oral health-related behaviours were related to diet related oral health behaviors.

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