Patterns of dietary behaviours identified by latent class analysis are associated with chronic uninvestigated dyspepsia

Ammar Hassanzadeh Keshteli[1,2], Awat Feizi[3], Ahmad Esmaillzadeh[4,5]*, Fatemeh Zaribaf[5], Christine Feinle-Bisset[6]†, Nicholas J. Talley[7,8] and Peyman Adibi[1]

[1]*Integrative Functional Gastroenterology Research Center, Isfahan University of Medical Sciences, Isfahan, Iran*
[2]*Department of Medicine, University of Alberta, Edmonton, AB, Canada*
[3]*Department of Epidemiology and Biostatistics, School of Public Health, Isfahan University of Medical Sciences, Isfahan, Iran*
[4]*Food Security Research Center, Isfahan University of Medical Sciences, Isfahan, Iran*
[5]*Department of Community Nutrition, School of Nutrition and Food Science, Isfahan University of Medical Sciences, PO Box 81745-151, Isfahan, Iran*
[6]*Discipline of Medicine, University of Adelaide, Adelaide, SA, Australia*
[7]*Division of Gastroenterology and Hepatology, Mayo Clinic, Rochester, MN, USA*
[8]*Faculty of Health, University of Newcastle, Callaghan, NSW, 2308, Australia*

Abstract

To our knowledge, no study has assessed the relationships between patterns of dietary behaviours, identified by latent class analysis (LCA), and chronic uninvestigated dyspepsia (CUD). The present study was conducted to determine the association between the patterns of dietary behaviours, identified by LCA, and CUD in a large sample of adults. In a cross-sectional study conducted on 4763 Iranian adults, we assessed the patterns of dietary behaviours in four domains, including 'meal patterns', 'eating rate', 'intra-meal fluid intake' and 'meal-to-sleep interval', as identified by LCA, using a pre-tested comprehensive questionnaire. Patients with CUD were identified using the Rome III diagnostic criteria. CUD was prevalent in 15·2 % (95 % CI 14·4, 16·2 %; *n* 723) of patients. Early satiation occurred in 6·3 % (*n* 302) of patients, bothersome post-prandial fullness in 8·0 % (*n* 384) of patients and epigastric pain in 7·8 % (*n* 371) of patients. We defined two distinct classes of meal patterns: 'regular' and 'irregular'. For eating rates, three classes were defined: 'moderate', 'moderate-to-slow' and 'moderate-to-fast'. Participants were identified as ingesting fluid with meals in two major classes: 'moderate intra-meal drinking' and 'high intra-meal drinking'. In terms of the interval between meals and sleeping, two distinct classes were identified: 'short meal-to-sleep interval' and 'long meal-to-sleep interval'. After controlling for potential confounders, the 'irregular meal pattern' was significantly associated with a greater odds of CUD (OR 1·42, 95 % CI 1·12, 1·78) compared with a 'regular meal pattern'. Individuals with a 'moderate-to-fast eating rate' were more likely to have CUD compared with those who had a 'moderate eating rate' (OR 1·42, 95 % CI 1·15, 1·75). Patterns of the 'meal-to-sleep interval' and 'intra-meal fluid intake' were not significantly associated with CUD. In conclusion, the 'irregular meal pattern' and the 'moderate-to-fast eating rate' were significantly associated with a greater odds of CUD. Further prospective investigations are warranted to confirm this association.

Key words: Dietary habits: Chronic uninvestigated dyspepsia: Functional gastrointestinal disorders: Meal regularity: Eating rates: Fluid intake

Functional dyspepsia (FD) has been defined as 'the presence of symptoms that originate in the gastro-duodenal region, in the absence of any organic, systemic or metabolic disease explaining the symptoms'[1]. Symptoms include postprandial fullness, early satiation, or epigastric pain or burning[1]. FD is the most common cause of dyspepsia[2]. It is an important public health problem, and its prevalence has been estimated to be 20–30 and 8–23 % in Western and Asian populations, respectively[1,3,4].

A recent systematic review in Iran[5] has reported that the prevalence of dyspepsia ranges from 2·9 to 29·9 % in different parts of the country. Although not life-threatening, FD reduces quality of life, imposes a considerable burden on the health care system and greatly increases health costs[6–8].

Several contributing factors including age, sex, ethnicity, smoking status, regular use of non-steroidal anti-inflammatory drugs and lifestyle have been shown to be related to dyspepsia[9].

Among lifestyle-related factors, diet may play a central role. Patients with FD frequently report that their symptoms are related to, or exacerbated by, eating (particularly fatty foods)[10–13]. Only a few studies[13–16] have evaluated the role of dietary macronutrients. For example, consumption of a high-fat meal has been shown to induce nausea and pain[13], and the effects have been found to be greater when compared with the consumption of a high-carbohydrate meal in FD patients[14]. Dietary fibre has also been found to vary in patients with FD, with intake being higher[17], lower[18] or comparable[19] with that of healthy controls.

The available studies have mostly evaluated food intolerances in FD[17,19,20], and there is little and inconsistent information about dietary behaviour in patients with FD[17,21–24]. For example, while speed of eating, irregular meal patterns, number and size of meals, eating before bedtime and inter-meal interval have been associated with an increased risk of FD in some observational studies[21–23], such findings have not been confirmed by others[17,24]. While previous studies have assessed certain aspects of dietary behaviours, application of latent class analysis (LCA), a person-centred approach, has not been undertaken. LCA provides a unique opportunity to classify individuals according to behavioural subclasses. The application of this method results in the identification of subjects within each latent class who are highly similar to each other and uniquely different from those in other classes. Therefore, LCA allows for the identification of discrete dietary behaviour groups instead of considering them as a single behaviour in diet–disease relationships. Furthermore, previous studies have mostly been performed in Western countries, and limited data are available in developing countries, where dietary intakes and dietary behaviours may be substantially different from those in developed nations. Given the limited information available, the best dietary management of dyspepsia remains uncertain, and available dietary strategies are limited. Therefore, identification of particular dietary behaviours that are associated with dyspepsia may allow the development of novel dietary treatment approaches for this condition. The aim of the present study was to determine the association between patterns of dietary behaviours, identified by LCA, and chronic uninvestigated dyspepsia (CUD) in a large cohort of Iranian adults.

Materials and methods

Participants

The present study was performed within the framework of the Study on the Epidemiology of Psychological, Alimentary Health and Nutrition (SEPAHAN) project, which is a cross-sectional study that investigates the epidemiological aspects of functional gastrointestinal disorders and their relationships with lifestyle measures and psychological factors. The study design, sample selection, characteristics of study participants as well as details on data collection methods have been described in Adibi *et al.*[25]. Briefly, the project was carried out by non-academic staff members of the Isfahan University of Medical Sciences (IUMS), Isfahan, Iran, who worked in hospitals, university campus and health centres affiliated

with the IUMS. To increase the accuracy of the collected data as well as the response rate, data collection was performed in two phases. In the first phase, a self-administered questionnaire on demographic and lifestyle factors, including nutritional habits and dietary intakes, was used (response rate 86·2%). In the second phase, a self-administered questionnaire containing questions on gastrointestinal function and psychological factors was used (response rate 64·6%). In the present analysis, we used the data from 4763 adults who had completed the questionnaire on both dietary habits and gastrointestinal symptoms. The Regional Bioethics Committee of IUMS approved the study protocol, and the participants provided written informed consent.

Assessment of dietary behaviours

Based on earlier studies[17,22,23], dietary behaviours were pre-defined and assessed in four domains ('meal patterns', 'eating rate', 'intra-meal fluid intake' and 'meal-to-sleep interval') using a detailed questionnaire, as summarised in Table 1.

Assessment of chronic uninvestigated dyspepsia

A modified Persian version of the Rome III questionnaire, as part of the main comprehensive questionnaire, was used for the assessment of functional gastrointestinal disorders, including CUD[25]. During the face validation of the questionnaire, we found that most participants were unable to distinguish between the descriptors used in the original Rome III questionnaire (never, less than 1 d per month, 1 d per month, 2–3 d per month, 1 d per week, more than 1 d per week, or every day). Therefore, we modified the rating scales to consist of only four descriptors (i.e. never or rarely, occasionally, often and always)[25]. In the present study, individuals with one or more of the following characteristics were defined as having CUD: bothersome postprandial fullness (defined as feeling uncomfortably full after eating a regular-sized meal, often or always); early satiation (defined as being unable to finish a regular-sized meal, often or always); epigastric pain or burning (defined as feeling pain or burning in the middle of the abdomen, often or always). The validity and reliability of the Persian version of the Rome III questionnaire in an Iranian population has been demonstrated previously[26].

Statistical analyses

The classes (subcategories of each domain) of dietary behaviours were identified by LCA, as detailed in Table 1. LCA examines the pattern of relationships among a set of observed categorical or continuous variables, and classifies individuals with similar behaviours into latent classes[27]. We used four main domains of dietary behaviours, each containing different indicators, as shown in Table 1. For each domain of dietary behaviour, we first applied a one-class model. Then, we sequentially increased the number of latent classes in order to determine the most parsimonious model. The interpretability of the obtained classes was also taken into account. For example, in the case of meal patterns, if a high percentage

Table 1. Questions used in latent class analysis for the participants of the SEPAHAN (Study on the Epidemiology of Psychological, Alimentary Health and Nutrition)

Meal pattern					
How many meals do you eat per d?	1		2		3
How often do you eat your meals regularly?	Never	Occasionally	Often		Always
How often do you eat breakfast during a week?	Never or once/week	2–4 times/week	5–6 times/week		Every day
How often do you eat lunch during a week?	Never or once/week	2–4 times/week	5–6 times/week		Every day
How often do you eat dinner during a week?	Never or once/week	2–4 times/week	5–6 times/week		Every day
Eating rate					
How thoroughly do you chew food?	Not very well		Well		Very well
How long does it take you to eat lunch?	Never eat lunch	<10 min	10–20 min		>20 min
How long does it take you to eat dinner?	Never eat dinner	<10 min	10–20 min		>20 min
Intra-meal fluid intake					
What is the temperature of fluids you drink with meals?	Not too cold		Cold		Very cold
How often do you drink fluids with meals or immediately before and after meals?	Never	Occasionally	Often		Always
How many glasses of fluids do you drink during meals?	≤1 glass	2–3 glasses	3–4 glasses		≥4 glasses
Meal-to-sleep interval					
How long does it take you to go to bed (or to lie down) after lunch?	Never sleep	<30 min	0·5–<2 h	2–4 h	>4 h
How long does it take you to go to bed (or to lie down) after dinner?	<30 min	0·5–<2 h	2–4 h	>4 h	
How long does it take you to go to bed (or to lie down) following the last snack after dinner?	Never eat snack	<30 min	0·5–2 h	>2 h	

of subjects responded that they eat three meals per d, eat meals regularly and eat breakfast, and eat lunch and dinner every day, such a pattern of dietary behaviour was considered as interpretable and was defined as a 'regular meal pattern'. During the application of LCA, those questions that did not significantly contribute to the construction of exclusive classes were excluded. Finally, based on the constructed classes for each dietary behaviour, the class memberships of the subjects were determined (i.e. four new binary or multinomial variables). These variables were used as the predictors of CUD for further analyses.

One-way ANOVA was used to compare continuous variables between the classes of dietary behaviours. Distribution of individuals in terms of categorical variables across the classes of dietary behaviours was examined using the χ^2 test. To determine the association between patterns of dietary behaviours and CUD, we used logistic regression analysis in different models. In other words, to find an independent association between each domain of dietary behaviours and CUD, we controlled for the mutual effects of the other dietary behaviours in the first model. Then, we added age and sex into the analysis. Further adjustments were made for physical activity and smoking status in the third model. We additionally controlled for BMI in the next model. Finally, we removed the other dietary behaviours from the model to determine the combined effects of dietary behaviours on CUD. In addition to the analyses for the whole population, we also conducted stratified analyses by sex and BMI status (<25 and ≥25 kg/m²).

LCA was performed using R free statistical software version 2.15.1 (R Foundation for Statistical Computing). All the other analyses were performed using the Statistical Package for Social Sciences (version 16.0; SPSS, Inc.). P values <0·05 (two-sided) were considered statistically significant.

Results

CUD was identified in 15·2% (95% CI 14·1, 16·2%; n 723) of patients. The occurrence of early satiation, bothersome post-prandial fullness, and epigastric pain or burning was 6·3% (n 302), 8·0% (n 384) and 7·8% (n 371), respectively. The latent classes identified by LCA, the distribution of participants (class size) and their responses to each question (item-specific response patterns in each class) in the four domains are presented in Table 2. For meal patterns across the entire population, two main classes were identified: 'regular' (n 2953, 62%) and 'irregular' (n 1810, 38%). For eating rate, three distinct classes were obtained: 'moderate' (n 3144, 66%); 'moderate-to-slow' (n 1143, 24%); 'moderate-to-fast' (n 476, 10%). In terms of intra-meal fluid intake, participants were categorised into two major classes: 'moderate intra-meal drinking' (n 2620, 55%) and 'high intra-meal drinking' (n 2143, 45%). In terms of the interval between meals and sleeping, two distinct classes were obtained: 'short meal-to-sleep interval' (n 3477, 73%) and 'long meal-to-sleep interval' (n 1286, 27%).

The general characteristics of the study participants across the different classes of dietary behaviours are provided in Table 3. Compared with those with a 'moderate eating rate', subjects with a 'moderate-to-fast eating rate' had higher weight and BMI. Those with a 'moderate-to-slow eating rate' tended to be older and more physically active compared with others. Subjects who drank more fluids with meals had higher BMI and weight and were less likely to be older, women and university-educated compared with those who were 'moderate fluid drinkers'. Participants with an 'irregular meal pattern' were more likely to be women, had higher BMI, prevalent CUD and epigastric pain compared with those who had a 'regular meal pattern'. Subjects with a 'long meal-to-sleep interval' were more likely to be single

Table 2. Latent classes identified by latent class analysis for the participants of the SEPAHAN (Study on the Epidemiology of Psychological, Alimentary Health and Nutrition)

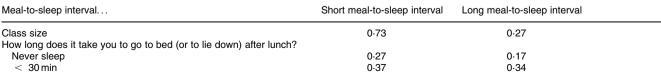| Type of dietary behaviours and their item-specific response patterns	Class-specific response patterns of participants		
Meal pattern...	Regular	Irregular	
Class size	0·62	0·38	
How many meals do you eat per d?			
1	0	0·09	
2	0·0067	0·66	
3	0·9933	0·25	
How often do you eat your meals regularly?			
Never	0·05	0·14	
Occasionally	0·27	0·40	
Often	0·47	0·37	
Always	0·21	0·09	
How often do you eat breakfast during a week?			
Never or once/week	0·01	0·18	
2−4 times/week	0·06	0·27	
5−6 times/week	0·09	0·13	
Every day	0·83	0·40	
How often do you eat lunch during a week?			
Never or once/week	0	0·02	
2−4 times/week	0·0004	0·07	
5−6 times/week	0·01	0·12	
Every day	0·99	0·78	
How often do you eat dinner during a week?			
Never or once/week	0·0068	0·19	
2−4 times/week	0·04	0·28	
5−6 times/week	0·12	0·20	
Every day	0·83	0·32	
Eating rate...	Moderate	Moderate-to-slow	Moderate-to-fast
Class size	0·66	0·24	0·10
How thoroughly do you chew food?			
Not very well	0·13	0·04	0·46
Well	0·76	0·69	0·53
Very well	0·1	0·27	0·01
How long does it take you to eat lunch?			
Never eat	0	0·03	0
< 10 min	0·07	0	0·99
10−20 min	0·92	0·21	0·01
> 20 min	0·0021	0·76	0
How long does it take you to eat dinner?			
Never eat dinner	0·04	0·23	0
< 10 min	0·18	0·06	0·96
10−20 min	0·66	0·50	0·03
> 20 min	0·1	0·2	0·0001
Intra-meal fluid intake...	Moderate intra-meal drinking	High intra-meal drinking	
Class size	0·55	0·45	
How often do you drink fluids with meals or immediately before and after meals?			
Never	0·11	0·0043	
Occasionally	0·60	0·15	
Often	0·24	0·38	
Always	0·04	0·46	
How many glasses of fluids do you drink during meals?			
≤ 1 glass	0·92	0·39	
2−3 glasses	0·08	0·50	
3−4 glasses	0·0008	0·07	
≥ 4 glasses	0	0·02	
What is the temperature of fluids you drink with meals?			
Not too cold	0·65	0·36	
Cold	0·34	0·60	
Very cold	0·0059	0·03	
Meal-to-sleep interval...	Short meal-to-sleep interval	Long meal-to-sleep interval	
Class size	0·73	0·27	
How long does it take you to go to bed (or to lie down) after lunch?			
Never sleep	0·27	0·17	
< 30 min	0·37	0·34	

Table 2. *Continued*

Type of dietary behaviours and their item-specific response patterns	Class-specific response patterns of participants	
Meal pattern...	Regular	Irregular
0·5– < 2 h	0·30	0·38
2–4 h	0·05	0·09
> 4 h	0·0093	0·02
How long does it take you to go to bed (or to lie down) after dinner?		
< 30 min?	0·03	0·0011
0·5– < 2 h	0·49	0·10
2–4 h	0·44	0·57
> 4 h	0·04	0·32
How long does it take you to go to bed (or to lie down) following the last snack after dinner?		
Never eat snacks	0·28	0
< 30 min	0·27	0
0·5–2 h	0·45	0·59
> 2 h	0·0009	0·4

and physically active compared with those with a 'short meal-to-sleep interval'.

Multivariable-adjusted OR for CUD across the different classes of dietary behaviours are presented in Table 4. After adjustment for age, sex and the mutual effects of the other dietary behaviours, the 'irregular meal pattern' was significantly associated with a greater odds of CUD (OR 1·41, 95% CI 1·15, 1·73). This association remained significant even after further controlling for smoking status and physical activity (OR 1·38, 95% CI 1·10, 1·73). When BMI was taken into account, the association did not change (OR 1·42, 95% CI 1·12, 1·78). After removing the other dietary behaviours from the model, we found that individuals with an 'irregular meal pattern' were 42% (OR 1·42, 95% CI 1·15, 1·75) more likely to have CUD compared with those who had a 'regular meal pattern'. We found that the 'moderate-to-fast eating rate' was not associated with the risk of CUD. However, when BMI was taken into account, the association became just significant (OR 1·41, 95% CI 1·00, 1·99). Exclusion of the other dietary behaviours slightly strengthened this association (OR 1·49, 95% CI 1·09, 2·03). No significant associations were found between the patterns of 'meal-to-sleep interval' and 'intra-meal fluid intake' and CUD.

When we examined the associations separately for men and women (Table 5), we found that men with a 'moderate-to-fast eating rate' were more likely to have CUD compared with those who had a 'moderate eating rate' (OR 2·22, 95% CI 1·31, 3·76). No other significant associations were found between dietary behaviours and CUD in men. The 'irregular meal pattern' was associated with a greater odds of CUD in women even after taking into account potential confounders such as age, sex, physical activity, smoking status, BMI and the mutual effects of the other dietary behaviours (OR 1·48, 95% CI 1·12, 1·95).

Stratified analyses by BMI status revealed that normal-weight individuals with an 'irregular meal pattern' tended to have a greater odds of CUD compared with their counterparts who had a 'regular meal pattern' (OR 1·55, 95% CI 1·15, 2·10; Table 6). 'High intra-meal fluid drinking' was marginally associated with a higher odds of CUD compared with

'moderate drinking' in normal-weight subjects (OR 1·33, 95% CI 0·99, 1·78). We also found that overweight individuals with a 'moderate-to-fast eating rate' were more likely to have CUD compared with those who had a 'moderate eating rate' (OR 1·74, 95% CI 1·07, 2·83). No further associations were found between dietary behaviours and CUD either in normal- or overweight participants.

Discussion

The present study provides novel insights into the association of dietary factors in CUD. We found a significant positive association between the 'irregular meal pattern' and the risk of CUD. This was independent of potential confounders and the effect of other dietary behaviours. The 'moderate-to-fast eating rate' was significantly associated with an increased risk of CUD after taking potential confounders into account. In contrast, the 'long meal-to-sleep interval' was not related to CUD, and no significant relationship was observed between 'intra-meal fluid intake' and the risk of CUD. To our knowledge, this is the first epidemiological study in which distinct classes of dietary behaviours identified by LCA have been related to CUD. The Rome III diagnostic criterion for FD requires endoscopic examination to exclude organic diseases. As we could not perform endoscopic evaluations, we assessed the association between dietary behaviours and CUD. However, it should be noted that here we compare our findings with other investigations that evaluate FD.

Dyspepsia affects a huge number of people worldwide. Although not life-threatening, this condition reduces quality of life to an extent comparable with mild heart failure and menopause[8]. Due to the heterogeneous nature of functional gastrointestinal disorders, their underlying causes have not been thoroughly identified, and no effective medication is available for their treatment. Genetic factors are involved in the aetiology of functional gastrointestinal disorders[28]; however, lifestyle-related factors are assumed to play a key modulator role[29]. Although a large proportion of patients with FD report that their symptoms are related to, or exacerbated after, meal intake[23,30], the role of both dietary intake and dietary

Table 3. General characteristics of the study participants across the different classes of dietary behaviours in the SEPAHAN (Study on the Epidemiology of Psychological, Alimentary Health and Nutrition)

(Mean values and standard deviations)

| | Meal pattern | | | | | Eating rate | | | | | | | Intra-meal fluid intake | | | | | Meal-to-sleep-interval | | | | |
| | Regular | | Irregular | | | Moderate | | Moderate-to-slow | | Moderate-to-fast | | | Moderate intra-meal drinking | | High intra-meal drinking | | | Short meal-to-sleep | | Long meal-to-sleep | | |
	Mean	SD	Mean	SD	P^*	Mean	SD	Mean	SD	Mean	SD	P^*	Mean	SD	Mean	SD	P^*	Mean	SD	Mean	SD	P^*
Age (years)	36·3	8·1	36·8	8·1	0·07	36·1	7·9	37·9	8·6	36·4	7·8	0·001	36·9	8·1	35·7	8·1	<0·001	36·5	8	36·6	8·4	0·92
Weight (kg)	68·6	12·5	68·6	12·8	0·91	68·3	12·5	68·9	13	71·4	13	0·001	67·6	12·3	70·5	13	<0·001	68·5	12·5	68·8	13	0·61
BMI (kg/m^2)	24·7	3·7	25·07	4	0·01	24·8	3·8	24·8	3·9	25·6	4·1	0·001	24·8	3·8	25·09	3·9	0·02	24·9	3·8	24·9	3·9	0·91
Female (%)	53		64		<0·001	59		51		51		0·001	62		50		<0·001	57		57		0·87
Married (%)	82		80		0·04	81		81		82		0·92	81		81		0·85	83		77		0·001
Current smokers (%)	3		4		0·17	3		5		3		0·06	3		4		0·59	3		4		0·72
Physical activity ≥1 h/d (%)	35		34		0·66	33		40		32		0·001	34		35		0·41	32		44		0·001
University education (%)	59		57		0·19	61		50		55		0·001	61		54		<0·001	58		58		0·76
Gastrointestinal disorders (%)																						
Chronic uninvestigated dyspepsia†	13		19		<0·001	15		14		18		0·13	14		16		0·11	15		14		0·64
Postprandial fullness‡	7		11		<0·001	8		8		9		0·74	8		9		0·17	8		7		0·65
Epigastric pain or burning§	7		9		0·004	8		8		9		0·38	8		8		0·67	8		6		0·05
Early satiation‖	55		45		<0·001	69		19		12		0·75	59		61		0·30	83		17		0·58

* P values were determined using ANOVA for continuous variables and χ^2 test for categorical variables.
† Participants with chronic uninvestigated dyspepsia were defined according to the Rome III diagnostic criteria as having one or more of the following characteristics: bothersome postprandial fullness (often or always); early satiation (often or always); epigastric pain or burning (often or always).
‡ Postprandial fullness was defined as feeling uncomfortably full after eating a regular-sized meal, often or always.
§ Epigastric pain or burning was defined as feeling pain or burning in the middle of the abdomen, often or always.
‖ Early satiation was defined as being unable to finish a regular-sized meal, often or always.

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Table 4. Multivariable-adjusted OR for chronic uninvestigated dyspepsia across the different classes of dietary behaviours for the participants of the SEPAHAN (Study on the Epidemiology of Psychological, Alimentary Health and Nutrition)

(Odds ratios and 95 % confidence intervals)

	Meal pattern			Eating rate						Intra-meal fluid intake			Meal-to-sleep-interval		
		Irregular			Moderate-to-slow		Moderate-to-fast				High intra-meal drinking			Long meal-to-sleep	
	Regular	OR	95 % CI	Moderate	OR	95 % CI	OR	95 % CI	Moderate intra-meal drinking	OR	95 % CI	Short meal-to-sleep	OR	95 % CI
Chronic uninvestigated dyspepsia*														
Crude model	1·00	1·53	1·29, 1·81	1·00	0·95	0·77, 1·17	1·26	0·98, 1·63	1·00	1·14	0·96, 1·35	1·00	0·94	0·75, 1·18
Model 1†	1·00	1·51	1·25, 1·82	1·00	0·94	0·74, 1·19	1·22	0·92, 1·61	1·00	1·19	0·99, 1·43	1·00	0·93	0·72, 1·18
Model 2‡	1·00	1·41	1·15, 1·73	1·00	1·02	0·79, 1·32	1·29	0·95, 1·76	1·00	1·18	0·96, 1·45	1·00	0·94	0·72, 1·22
Model 3§	1·00	1·38	1·10, 1·73	1·00	0·99	0·74, 1·32	1·32	0·94, 1·85	1·00	1·20	0·96, 1·5	1·00	0·92	0·69, 1·24
Model 4‖	1·00	1·42	1·12, 1·78	1·00	0·96	0·71, 1·30	1·41	1·00, 1·99	1·00	1·21	0·96, 1·52	1·00	0·93	0·69, 1·26
Model 5¶	1·00	1·42	1·15, 1·75	1·00	0·98	0·75, 1·28	1·49	1·09, 2·03	1·00	1·17	0·95, 1·45	1·00	1·01	0·76, 1·33

* Patients with chronic uninvestigated dyspepsia were defined according to the Rome III diagnostic criteria as having one or more of the following characteristics: bothersome postprandial fullness (often or always); early satiation (often or always); epigastric pain or burning (often or always).
† Model 1 was adjusted for other dietary behaviours.
‡ Model 2 was adjusted for other dietary behaviours, age and sex.
§ Model 3 was adjusted for other dietary behaviours, age, sex, physical activity and smoking status.
‖ Model 4 was adjusted for other dietary behaviours, age, sex, physical activity, smoking status and BMI.
¶ Model 5 was adjusted for age, sex, physical activity, smoking status and BMI.

Table 5. Multivariable-adjusted OR for chronic uninvestigated dyspepsia across the different classes of dietary behaviours stratified by sex for the participants of the SEPAHAN (Study on the Epidemiology of Psychological, Alimentary Health and Nutrition)

(Odds ratios and 95 % confidence intervals)

	Meal pattern			Eating rate						Intra-meal fluid intake			Meal-to-sleep interval		
		Irregular			Moderate-to-slow		Moderate-to-fast				High intra-meal drinking			Long meal-to-sleep	
	Regular	OR	95 % CI	Moderate	OR	95 % CI	OR	95 % CI	Moderate intra-meal drinking	OR	95 % CI	Short meal-to-sleep	OR	95 % CI
Men														
Crude model	1·00	1·45	1·08, 1·96	1·00	1·17	0·84, 1·64	1·78	1·21, 2·61	1·00	1·20	0·90, 1·6	1·00	1·03	0·70, 1·5
Model 1*	1·00	1·50	1·08, 2·08	1·00	1·24	0·84, 1·82	1·73	1·13, 2·65	1·00	1·18	0·86, 1·61	1·00	1·00	0·66, 1·51
Model 2†	1·00	1·36	0·94, 1·97	1·00	1·30	0·85, 1·97	1·69	1·04, 2·75	1·00	1·18	0·83, 1·67	1·00	0·88	0·55, 1·42
Model 3‡	1·00	1·18	0·79, 1·75	1·00	1·42	0·91, 2·22	1·88	1·13, 3·14	1·00	1·24	0·85, 1·8	1·00	0·89	0·53, 1·48
Model 4§	1·00	1·25	0·83, 1·90	1·00	1·40	0·87, 2·25	2·22	1·31, 3·76	1·00	1·23	0·83, 1·82	1·00	0·90	0·52, 1·56
Model 5‖	1·00	1·21	0·84, 1·75	1·00	1·27	0·84, 1·91	2·14	1·34, 3·4	1·00	1·22	0·86, 1·73	1·00	0·99	0·61, 1·61
Women														
Crude model	1·00	1·47	1·19, 1·82	1·00	0·85	0·64, 1·13	1·14	0·80, 1·60	1·00	1·23	0·99, 1·53	1·00	0·95	0·71, 1·26
Model 1	1·00	1·42	1·13, 1·79	1·00	0·82	0·59, 1·12	1·08	0·74, 1·58	1·00	1·30	1·02, 1·65	1·00	0·92	0·68, 1·26
Model 2	1·00	1·43	1·12, 1·83	1·00	0·90	0·64, 1·24	1·12	0·75, 1·66	1·00	1·19	0·92, 1·52	1·00	0·97	0·7, 1·35
Model 3	1·00	1·48	1·13, 1·95	1·00	0·79	0·54, 1·16	1·05	0·66, 1·65	1·00	1·18	0·89, 1·56	1·00	0·95	0·66, 1·37
Model 4	1·00	1·48	1·12, 1·95	1·00	0·78	0·53, 1·16	1·07	0·67, 1·71	1·00	1·21	0·91, 1·61	1·00	0·96	0·66, 1·38
Model 5	1·00	1·52	1·18, 1·97	1·00	0·84	0·59, 1·19	1·17	0·77, 1·79	1·00	1·16	0·89, 1·51	1·00	1·02	0·73, 1·44

* Model 1 was adjusted for other dietary behaviours.
† Model 2 was adjusted for other dietary behaviours and age.
‡ Model 3 was adjusted for other dietary behaviours, age, physical activity and smoking status.
§ Model 4 was adjusted for other dietary behaviours, age, physical activity, smoking status and BMI.
‖ Model 5 was adjusted for age, physical activity, smoking status and BMI.

Table 6. Multivariable-adjusted OR for chronic uninvestigated dyspepsia across the different classes of dietary behaviours stratified by BMI for the participants of the SEPAHAN (Study on the Epidemiology of Psychological, Alimentary Health and Nutrition)

(Odds ratios and 95 % confidence intervals)

| | Meal pattern | | | Eating rate | | | | | Intra-meal fluid intake | | | Meal-to-sleep interval | | |
| | Regular | Irregular | | Moderate | Moderate-to-slow | | Moderate-to-fast | | Moderate intra-meal drinking | High intra-meal drinking | | Short meal-to-sleep | Long meal-to-sleep | |
		OR	95 % CI		OR	95 % CI	OR	95 % CI		OR	95 % CI		OR	95 % CI
BMI <25 kg/m²														
Crude model	1·00	1·53	1·21, 1·93	1·00	0·82	0·61, 1·09	1·28	0·89, 1·84	1·00	1·31	1·04, 1·65	1·00	1·08	0·81, 1·44
Model 1*	1·00	1·57	1·22, 2·03	1·00	0·79	0·57, 1·1	1·05	0·7, 1·58	1·00	1·32	1·03, 1·7	1·00	1·02	0·75, 1·4
Model 2†	1·00	1·52	1·15, 2	1·00	0·85	0·6, 1·2	0·94	0·59, 1·49	1·00	1·35	1·03, 1·77	1·00	0·99	0·7, 1·4
Model 3‡	1·00	1·55	1·15, 2·1	1·00	0·90	0·62, 1·32	1·06	0·64, 1·76	1·00	1·33	0·99, 1·78	1·00	1·01	0·69, 1·47
Model 4§	1·00	1·49	1·13, 1·96	1·00	0·91	0·65, 1·29	1·35	0·87, 2·09	1·00	1·38	1·05, 1·82	1·00	1·13	0·8, 1·6
BMI >25 kg/m²														
Crude model	1·00	1·42	1·09, 1·85	1·00	1·17	0·84, 1·62	1·39	0·96, 2·02	1·00	0·91	0·7, 1·19	1·00	0·80	0·54, 1·16
Model 1	1·00	1·39	1·03, 1·86	1·00	1·17	0·8, 1·7	1·56	1·04, 2·34	1·00	1·00	0·74, 1·35	1·00	0·82	0·54, 1·24
Model 2	1·00	1·30	0·95, 1·79	1·00	1·29	0·85, 1·95	1·87	1·21, 2·88	1·00	0·98	0·7, 1·36	1·00	0·83	0·54, 1·3
Model 3	1·00	1·21	0·84, 1·74	1·00	1·10	0·67, 1·8	1·74	1·07, 2·83	1·00	1·03	0·71, 1·49	1·00	0·76	0·45, 1·29
Model 4	1·00	1·31	0·95, 1·8	1·00	1·11	0·73, 1·67	1·62	1·04, 2·53	1·00	0·93	0·67, 1·3	1·00	0·79	0·49, 1·28

* Model 1 was adjusted for other dietary behaviours.
† Model 2 was adjusted for other dietary behaviours, age and sex.
‡ Model 3 was adjusted for other dietary behaviours, age, sex, physical activity and smoking status.
§ Model 4 was adjusted for age, sex, physical activity and smoking status.

behaviours, including meal patterns, eating rate, intra-meal fluid intake and meal-to-sleep interval, have, to date, not received sufficient attention and, thus, require further consideration.

In the present study, an irregular meal pattern was associated with a greater risk of having CUD. This finding is in line with the results of a population-based cross-sectional study in which irregular intake of meals was related to the symptoms of dyspepsia[21]. However, that study did not use LCA to identify dietary behaviours and did not take into account the effect of other variables. The association of an irregular meal pattern with irritable bowel syndrome and FD has also been reported in a case–control study in Japan[31] and by others[20,32]. Not all studies have detected a significant association between meal patterns and FD[17,24]; this discrepancy may be due to the case–control design and small sample sizes of these studies. Furthermore, such studies have not matched cases and controls for age, marital status and socio-economic status, all of which may confound dietary behaviours[33,34]. In addition, the influence of other dietary behaviours including eating rate, intra-meal fluid intake and meal-to-sleep interval has not been controlled in these studies. It has been shown that patients with FD ate fewer full meals compared with healthy individuals, and, instead, consumed a more smaller meal[23]. These findings suggest that patients with FD may reduce their meal size and/or eat irregularly in an attempt to alleviate their symptoms.

We also found a significant association between eating rate and the risk of CUD. Similar to the present results, Sinn *et al.*[22] found that a higher percentage of women with FD had a faster eating rate than healthy control subjects. Theoretically, fast eating may overload normal reflex responses such as fundic relaxation, which, if impaired for other reasons, may lead to dyspepsia. However, not all studies agree. Carvalho *et al.*[17] showed that the same percentage of patients with FD and healthy subjects regarded themselves as fast eaters. However, interpretation of their results is difficult, because no clear definition of 'fast eater' was provided. In the study of Sinn *et al.*[22], fast eating obtained from the questionnaires could not be confirmed when the investigators assessed it objectively. It must also be kept in mind that in the present study, participants perceived themselves as fast eaters. To what extent this could reflect truly fast eating needs to be further assessed.

We did not find significant associations between the pattern of intra-meal fluid intake or meal-to-sleep interval and CUD. These observations are in accordance with the limited available data from previous investigations. Earlier studies have found that the duration of the overnight fast and the percentage of individuals who went to bed soon after having their meal did not differ significantly between patients with FD and controls[17]. We did not find any evidence supporting a link between intra-meal fluid intake and CUD, in line with the only other investigation quantifying drinking episodes in patients with FD and healthy subjects[23].

The present data also provide evidence that the associations between dietary behaviours and CUD are modified by sex and BMI. Men with a 'moderate-to-fast eating rate' were more likely to have CUD compared with those who had a

'moderate eating rate'. Notably, an 'irregular meal pattern' was associated with a greater odds of CUD only in women. The influence of sex or BMI on these associations has not been investigated previously.

It is important to recognise some strengths, as well as potential limitations, of the present study. A major strength is the application of LCA to define discrete dietary behaviours instead of considering them as a single behaviour in diet–disease relationships. Furthermore, the associations reported in the present study were probably independent of other dietary behaviour categories due to controlling for the mutual effects in statistical models. The large sample size is the strength of the present study. Limitations include the cross-sectional nature of the study, as a result of which we cannot infer cause–effect relationships from our findings. Furthermore, there is no clear-cut evidence that symptoms influence dietary habits. This may be the case in some patients, but not in others[23,24]. To identify the real association between symptoms of dyspepsia and dietary behaviours, further prospective cohort investigations are required. However, due to budget restriction, we did not assess such relationship within the framework of a large prospective cohort. Participants of the present study were 20 to 50 years of age and non-academic staff members of the IUMS. Since the participants in the present study were working in health centres, they may have a healthier lifestyle. Thus, extrapolation of the present findings to the general population in Iran, as well as to other cultural backgrounds, must be done with caution. Despite the adjustment for several lifestyle variables, residual confounding cannot be excluded. Many lifestyle factors such as coffee consumption and emotional experience, which were not controlled for in the present study, may also contribute to the occurrence of dyspepsia. It should also be kept in mind that all information that we used in the present analysis was collected by self-administered questionnaires, and this method of data collection might misclassify participants. However, this is a problem in all epidemiological studies. These misclassifications would move the OR to non-significant associations. Considering the associations that we found, it seems that these associations are much stronger in reality.

In conclusion, we found that dietary behaviours identified by LCA, in particular 'irregular meal pattern' and 'fast eating rate', are associated with an increased risk of CUD. These associations were modified by sex and BMI, such that men with a 'moderate-to-fast eating rate' were more likely to have CUD compared with those who had a 'moderate eating rate', while an 'irregular meal pattern' was associated with a greater odds of CUD only in women. Further prospective investigations are required to explore these findings and the links to the pathophysiology.

Acknowledgements

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