Dietary patterns and smoking in Northern Irish men: a population at High risk of coronary heart disease

Original Communication

Dietary Patterns and Smoking in Northern Irish Men: a Population at High Risk of Coronary Heart Disease

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Abstract: This study evaluated dietary habits of Northern Irish men who are at high risk of cardiovascular disease, stratified as never-, ex-, moderate-, or heavy-smokers. Participants were male volunteers (30–49 years) from a single workforce in Belfast ($n = 765$). Dietary information was collected using a validated food frequency questionnaire. For *'a priori'* diet scores, never- and ex-smokers had a significantly higher fruit and vegetable score, Mediterranean diet score, and alternative Mediterranean diet score than moderate or heavy-smokers (all $p < 0.05$). For *'a posteriori'* patterns, scores for the healthy, sweet tooth, and traditional dietary patterns, derived from principal component analysis, differed significantly by smoking status, being lower among smokers for the healthy and sweet tooth patterns, and higher in ex-smokers for the traditional pattern (all $p < 0.05$). When the *'a posteriori'* patterns were included in models predicting likelihood of being in a particular smoking category with the *'a priori'* patterns, the results for the fruit and vegetable score lost significance ($p = 0.13$). Both *'a priori'* and *'a posteriori'* dietary patterns identified smokers, particularly heavy smokers, as exhibiting fewer healthy dietary habits than never- or ex-smokers, but *'a posteriori'* dietary patterns appeared to be more strongly associated with smoking status.

Key words: Mediterranean diet score, cardiovascular disease, fruit, vegetable, smoking, dietary patterns, principal component analysis.

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Introduction

Cigarette smoking is a major risk factor for cardiovascular disease (CVD), as well as for respiratory conditions and cancer. Cigarette smoke contains pro-oxidants which contribute to these adverse health effects. However, other lifestyle behaviors, including dietary habits could be involved [1], as smokers and non-smokers differ in their food choices and in their dietary intakes of micronutrients, macronutrients, and alcohol [1–4]. This may result in an imbalance between increased oxidative stress and impaired antioxidant defense, especially inactivation of nitric oxide (NO) by superoxide and other reactive oxygen species, contributing to endothelial dysfunction and the pathogenesis of cardiovascular events [5].

Earlier studies looking at smoking in relation to diet have focused predominantly on individual dietary constituents [6]. However, given the complexity of human diets, high correlations between intakes of various nutrients or food items, and the many nutrient-to-nutrient biochemical interactions, the effects of consumption level of a single nutrient or food on a specific health outcome, may be spurious [7]. Additionally, dietary pattern analysis allows for examination of the combined and potentially synergistic effects of many correlated dietary exposures, and a dietary pattern approach is capable of capturing complex interactions between dietary components and health beyond the sum of each nutrient.

Two distinct approaches for examining dietary patterns are evident in the literature. One approach (*a priori*) is based on existing hypotheses and guidance about the role of nutrients in disease prevention, and dietary-quality scores are generated based on recommended diets or guidelines; e.g., the Diet Quality Index [8], the Healthy Eating Index [9], and the Mediterranean Diet Score [10]. The second approach is data-driven (*a posteriori*), with dietary patterns summarized using statistical techniques such as factor analysis (principal components analysis (PCA)) [6, 11], cluster analysis [6], and reduced rank regression [12]. However, dietary patterns are likely to vary according to sex, socioeconomic status, ethnic group, and cultures, making it necessary to replicate results in diverse populations. Regardless, whether overall dietary habits vary by number of cigarettes smoked, and whether ex-smokers resemble never- or current-smokers are intriguing questions, especially as poorer dietary behaviors seem to be positively associated with cigarette consumption [3, 13–15].

The aim of this study was to assess the dietary habits of a Northern Irish male population (30–49 years), who are at high risk of CVD. Heart disease and CVD is the main cause of death in Northern Ireland. In 2007 it accounted for nearly 5,000 deaths: nearly a third of all deaths. CVD is also a major cause of premature death (death before the age of 75), and accounted for over a quarter (27 %) of premature deaths in men in 2007 [16]. We determined both *'a priori'* and *'a posteriori'* dietary patterns from food frequency questionnaire (FFQ) data, and determined whether these patterns differed between never-, ex-, moderate- (<20 cigarettes/day), and heavy-smokers (≥ 20 cigarettes/day).

Subjects and methods

Participants

Participants were Northern Irish male volunteers aged 30–49 years from a single workforce and included manual, clerical, administrative, and executive grades. A list of employees within the target age-group was obtained from the Occupational Health Unit at Shorts Brothers, Belfast and contacted by letter. Subjects attended a clinic in the Occupational Health Unit (n = 765). A brief medical history was taken and height and weight measured. Subjects who were diabetic or had had a general anesthetic within the past three months were excluded.

Nutritional Assessment

Each subject was asked to complete a self administered, semi-quantitative, FFQ before attending the clinic, where advice in its completion was available. The FFQ used was previously validated in a similar UK population [17], and was adapted to collect information on food items whose availability had changed over time.

The majority of the questions concerned the frequency of consumption of common food items, recorded as the number of times each item was consumed weekly. Quantity consumed was also recorded for some food items; including bread, milk, eggs, and cheese. Type of milk, spreading fat, cooking oil, and drinks consumed were also recorded.

Information on smoking habits was obtained on whether the participants were current smokers or had ever been regular smokers, and details of the number of cigarettes smoked per day was recorded. Subjects were then classified as never-, ex-, moderate-, (<20 cigarettes/day) or heavy-smokers (>= 20 cigarettes/day).

Calculation of diet patterns – 'a priori'

Fruit and vegetable score (FVS)

All applicable responses from the FFQ were re-coded into daily portions and combined to form the overall FVS score (daily intakes of all fruit and vegetables and natural fruit juice). A portion of fruit and vegetables was defined according to UK Food Standard Agency guidelines (www.eatwell.gov.uk).

Mediterranean Diet Score (MDS)

All applicable responses from the FFQ were re-coded into daily portions and combined to form nine MDS components (Table I). Values of 0 and 1 were assigned to each of the nine components of the Mediterranean diet; intakes of beneficial components (olive oil, fruit, vegetables, salad, legumes, whole-grain bread, wine) above the median consumption were assigned a 1, and 0 for detrimental components (white bread, rice, meat). Therefore, the MDS ranged from 0 (minimal adherence) to 9 (maximum adherence). An alternative version of the MDS was also calculated (altMDS) [18]. Instead of using sex-specific medians as the cut-off for determining individual scores, servings per day/week were used (Table I).

Calculation of diet patterns – 'a posteriori'

The 90 food items from the FFQ were aggregated into 54 food groups, defined by similarity in nutrient content/culinary use (Appendix 1). PCA was used to identify patterns of dietary consumption. PCA identifies common underlying dimensions (factors or patterns) of food consumption by aggregating specific food items/food groups on the basis of the degree to which food items in the dataset are correlated with one another – see reference 11 for an excellent description of PCA. Frequency of intake for a food group was calculated as the sum of the servings/week for the individual food items. For each food group, the frequency of intake was adjusted for total energy intake, using the residual method [19]. The energy-adjusted intakes were standardized to Z-scores, and these were used in the PCA. Factors with eigenvalues above 1.8 were retained for analyses and factor loadings of >0.25 were considered as important (Appendix 1).

The scree plot of the first twenty components from the PCA displayed elbows after the fourth and fifth components. As components one to five were interpretable in terms of plausible dietary patterns, these were retained. The total variance explained by the first five components was 23 %.

The five patterns identified were the *Healthy:* frequent intakes of wholemeal bread, high-fiber breakfast cereals, white meat, oily fish, fruit and vegetables, spaghetti, rice, and semi-skimmed milk, low intakes of whole milk, white bread, and processed meat; *Sweet tooth:* frequent intakes of sugary cereals, cakes, bis-

Table I: Dietary components included in both the Mediterranean Diet Score (medians) and the alternative Mediterranean Diet Score (servings).

Mediterranean Diet Component	A value of 1 was given if the subject satisfied the following criteria	
	Mediterranean Diet Score	alternative Mediterranean Diet Score
i. Olive oil	≥ median cut-off	≥1 spoon/day
ii. Fruit	≥ median cut-off	≥1 serving/day
iii. Vegetables OR salad	≥ median cut-off	≥1 serving/day
iv. Fruit AND vegetables[1]	≥ median cut-off	≥1 serving/day
v. Legumes	≥ median cut-off	≥2 serving/week
vi. Fish	≥ median cut-off	≥3 serving/week
vii. Wine	≥ median cut-off	≥1 glass/day
vii. Meat	< median cut-off	<1 serving/day
ix. (White bread AND rice) OR whole-grain bread[2]	median cut-offs	<1 /day AND <1 /week OR >5 /week

[1] One point is added when ≥1 serving/day of BOTH fruits and vegetables is consumed.
[2] One point added when either consumption of BOTH white bread and rice is low OR consumption of whole-grain bread is high.

cuits, sweets and added sugar, and low intakes of alcohol; *Low Vegetable:* frequent intakes of chocolate, sweets, and sherry, low intakes of green and yellow vegetables and baked beans; *Traditional:* frequent intakes of red meat, plain potatoes, vegetables, and whole milk, low intakes of semi-skimmed milk; *Fast food:* frequent intakes of processed meat, fried potatoes, and crisps.

Biomarkers of CVD risk and nutrient status

Biomarkers of CVD risk and nutrient status were additionally examined alongside the dietary patterns to further investigate associations between never-, ex-, moderate-, and heavy-smokers, and to see how these associations compared with what was reported for the dietary patterns. Concentrations of serum folate were measured using an ICN Pharmaceuticals kit (California, USA). Concentrations of serum vitamin E and carotenoids were measured by high-performance liquid chromatography (HPLC) [20, 21]. Cholesterol was estimated using an enzymatic CHOD-PAP kit, and triglycerides using the Peridochrom GPO-PAP kit (Boehringer Mannheim, Germany).

Statistical Methods

All analyses were performed using SPSS 14.0 for Windows (SPSS Inc, Chicago, IL), except for ordinal logistic regression, which was carried out using Stata version 9.2, (Timberlake Consultants, London, UK).

Chi-square statistics were used to compare categorical variables by smoking status. Population characteristics, lipid concentrations, antioxidant vitamins, and carotenoids are presented as geometric means [interquartile range (IQR)]. Data for the *'a priori'* dietary patterns are presented as median (IQR) and mean [standard deviation (SD)] for the *'a posteriori'* dietary patterns. These variables were compared between smoking groups using one-way analysis of variance (ANOVA). Differences were tested for crude values and after adjustment for possible confounding factors such as age, body mass index (BMI), shift work, vitamin supplement use, alcohol intake, and micronutrient intake.

A multinomial logistic regression model was used to estimate whether the *'a priori'* or *'a posteriori'* dietary patterns were associated with the likelihood of being an ex-, moderate- or heavy-smoker [22]. Likelihood ratio tests were performed to obtain p-values to evaluate the inclusion/exclusion of the dietary pattern variable in question in the multinomial models.

Table II: Population characteristics by smoking status.[1]

	Never smokers	Ex-smokers	Smokers		p-value	p-value
	(n = 423)	(n = 161)	Moderate <20 cigarettes/day (n = 105)	Heavy ≥20 cigarettes/day (n = 72)	(ANOVA or chi-square)	(Univariate Analysis)[3]
Current cigarette consumption (cigs/day)	–	–	5 (1, 14)[a]	23 (20, 27)[b]	≤0.001	–
Age (years)	37.6 (33.2, 42.1)[a]	41.5 (37.6, 47.4)[c]	39.4 (34.3, 42.8)[b]	38.4 (35.1,42.1)[ab]	≤0.001	–
Regularly working shifts (%)	24.6	34.8	33.3	52.8	≤0.001[2]	–
Multivitamin supplements (%)	21.3	19.9	9.5	8.3	0.005[2]	–
BMI (kg/m^2)	25.6 (23.8, 27.2)	26.5 (25.1, 28.4)	26.3 (24.6, 28.1)	26.1 (24.0, 27.7)	0.005	0.019
Systolic BP (mmHg)	126.6 (118,135)	128.7 (119, 138.5)	128.5 (119, 138.5)	127.1 (119,136)	0.333	0.618
Diastolic BP(mmHg)	78.6 (73, 84)	81.4 (76, 88)	79.9 (73, 87)	80.4 (76, 84)	0.010	0.290

Means within a row with different superscript letters are significantly different, p≤0.05 (Student-Neuman-Keuls multiple-range test).
[1] Geometric mean (interquartile range); [2] Total p value of chi-square test; [3] Adjusted for age.

Table III: Dietary patterns by smoking status.

Dietary pattern	Smoking category	N	Median (IQR) / Mean (SD)	p-value	Adjusted difference (95 % CI)[3]	p-value (p for trend)
Fruit and Vegetable Score	Never smokers	423	2.78 (2.00, 3.57)[1]	0.001	Referent	0.007 (0.006)
	Ex-smokers	161	2.72 (2.07, 3.71)[1]		0.09 (−0.13, 0.31)	
	Moderate smokers	105	2.36 (1.68, 3.44)[1]		−0.16 (−0.41, 0.09)	
	Heavy smokers	72	2.30 (1.75, 2.91)[1]		−0.45 (−0.75, −0.15)	
Mediterranean Diet Score	Never smokers	423	4 (3, 6)[1]	≤0.001	Referent	≤0.001 (≤0.001)
	Ex-smokers	161	4 (3, 6)[1]		0.13 (−0.21, 0.47)	
	Moderate smokers	105	3 (2, 5)[1]		−0.57 (−0.96, −0.18)	
	Heavy smokers	72	3 (2, 4)[1]		−1.09 (−1.55, −0.64)	
Alternative Mediterranean Diet Score	Never smokers	423	3 (2, 4)[1]	0.005	Referent	0.030 (0.030)
	Ex-smokers	161	3 (2, 5)[1]		0.17 (−0.13, 0.46)	
	Moderate smokers	105	2 (1, 4)[1]		−0.19 (−0.52, 0.15)	
	Heavy smokers	72	2 (2, 3)[1]		−0.45 (−0.85, −0.06)	
Healthy	Never smokers	423	0.18 (0.94)[2]	≤0.001	Referent	≤0.001 (≤0.001)
	Ex-smokers	161	0.03 (1.06)[2]		−0.11 (−0.29, 0.07)	
	Moderate smokers	105	−0.30 (0.95)[2]		−0.39 (−0.59, −0.18)	
	Heavy smokers	72	−0.67 (0.86)[2]		−0.72 (−0.96, −0.48)	
Sweet tooth	Never smokers	423	0.18 (1.00)[2]	≤0.001	Referent	≤0.001 (≤0.001)
	Ex-smokers	161	−0.03 (0.93)[2]		−0.18 (−0.36, 0.01)	
	Moderate smokers	105	−0.39 (0.88)[2]		−0.52 (−0.72, −0.31)	
	Heavy smokers	72	−0.42 (1.04)[2]		−0.58 (−0.82, −0.33)	
Low Vegetable Intake	Never smokers	423	0.04 (1.01)[2]	0.630	Referent	0.730 (0.640)
	Ex-smokers	161	−0.08 (0.98)[2]		0.11 (−0.08, 0.29)	
	Moderate smokers	105	−0.03 (1.03)[2]		0.03 (−0.18, 0.23)	
	Heavy smokers	72	−0.02 (0.99)[2]		0.04 (−0.2, 0.29)	
Traditional	Never smokers	423	−0.12 (1.02)[2]	0.002	Referent	0.040 (0.020)
	Ex-smokers	161	0.20 (0.91)[2]		0.25 (0.06, 0.43)	
	Moderate smokers	105	0.12 (0.96)[2]		0.20 (−0.02, 0.41)	
	Heavy smokers	72	0.10 (1.00)[2]		0.19 (−0.06, 0.45)	
Fast food	Never smokers	423	0.02 (0.98)[2]	0.680	Referent	0.900 (0.480)
	Ex-smokers	161	−0.08 (1.12)[2]		0.003 (−0.19, 0.19)	
	Moderate smokers	105	0.03 (0.91)[2]		0.05 (−0.16, 0.27)	
	Heavy smokers	72	0.05 (0.95)[2]		0.08 (−0.17, 0.34)	

Moderate smokers defined as <20 cigarettes/day; heavy smokers defined as ≥20 cigarettes/day.
[1]Median (interquartile range); [2]Mean (standard deviation); [3]Adjusted for age, BMI, shift work, and vitamin supplement use.

Results

The subjects' characteristics are presented by smoking status in Table II. Ex-smokers were older than never-smokers and those in both smoking groups. Mean (SD) time since stopping smoking was 7.0 (3.5) years. The percentage of those regularly working shifts was highest in heavy-smokers (52.8 %), and lowest in never-smokers (24.6 %). Vitamin supplement use also differed significantly, being highest in never-smokers (21.3 %) and lowest in heavy-smokers (8.3 %). Systolic and diastolic blood pressure did not differ, but BMI did differ with respect to smoking status, being higher in ex-, moderate-, and heavy-smokers than in never-smokers, although there were no homogeneous subsets.

Table IV: Lipid concentrations, antioxidant vitamins, and carotenoids by smoking status.[1]

	Never smokers	Ex-smokers	Smokers		p-value	p-value
			Moderate <20 cigarettes/day	Heavy ≥20 cigarettes/day	(ANOVA)	(Univariate Analysis)[2]
	(n_{max} = 423)	(n_{max} = 161)	(n_{max} = 105)	(n_{max} = 72)		
Serum Cholesterol (mmol/L)	5.60 (5.00, 6.31)	5.92 (5.30, 6.79)	5.91 (5.23, 6.56)	5.78 (5.03, 6.67)	0.003	0.536
HDL-cholesterol (mmol/L)	1.08 (0.93, 1.27)^a	1.06 (0.90, 1.25)^a	1.01 (0.84, 1.20)^{ab}	0.96 (0.80, 1.17)^b	0.003	≤0.001
Triglycerides (mmol/L)	1.40 (0.95, 2.09)^a	1.77 (1.17, 2.54)^b	1.84 (1.39, 2.38)^b	1.91 (1.27, 2.72)^b	≤0.001	0.001
Vitamin E (mmol/L)	27.68 (25.90, 38.88)	30.64 (28.37, 44.7)	33.79 (27.40, 41.29)	34.67 (29.45, 39.72)	0.218	0.397[3]
Lipid-standardized vitamin E (mmol/mmol)	4.94 (4.73, 6.71)	5.12 (5.04, 6.92)	5.65 (4.79, 6.88)	6.04 (5.06, 7.16)	0.436	0.437[3]
α-carotene (μmol/L)	0.04 (0.01,0.09)^a	0.03 (0.01, 0.86)^a	0.03 (0.01, 0.69)^{ab}	0.02 (0.01, 0.06)^b	0.006	0.014[3]
β-carotene (μmol/L)	0.33 (0.21, 0.55)^a	0.33 (0.21, 0.59)^a	0.26 (0.15, 0.43)^{ab}	0.24 (0.17, 0.37)^b	0.006	0.050[3]
Folate (nmol/L)	11.46 (8.97, 14.72)^a	11.7 (8.97, 14.72)^a	10.69 (7.94, 13.57)^{ab}	9.98 (7.30, 12.71)^b	0.040	0.123[3]

Means within a row with different superscript letters are significantly different, p≤0.05 (Student-Neuman-Keuls multiple-range test).
[1]Geometric mean (interquartile range); [2]Adjusted for age, alcohol intake, and BMI; [3]Adjusted for age, alcohol intake, BMI, and micronutrient intake.

The analysis of dietary patterns according to smoking status is presented in Table III. The *'a priori'* approaches, FVS, the MDS, and the altMDS, differed significantly by smoking status in unadjusted models (p=0.001, p≤0.001, p=0.005, respectively), with never- and ex-smokers having higher scores than the smoking groups for these three dietary patterns. These associations persisted in models adjusted for age, BMI, shift work and vitamin supplement use (p=0.007, p≤0.001, p=0.030, respectively). Heavy-smokers had a lower score compared to never-smokers (referent) for both the FVS and the altMDS, whilst both moderate- and heavy-smokers had a lower score for the MDS compared to never-smokers. The p for trend for the FVS, MDS, and altMDS showed that these scores decreased from never-smokers through to heavy-smokers (p=0.006, p≤0.001, p=0.030, respectively).

Scores for the *'a posteriori'* PCA-derived healthy, sweet tooth, and traditional dietary patterns also differed significantly by smoking status (p≤0.001, p≤0.001, p=0.002, respectively), and these associations persisted in models adjusted for age, BMI, shift work and vitamin supplement use (p≤0.001, p≤0.001, p=0.040, respectively). Moderate- and heavy-smokers had lower values for the healthy pattern and sweet tooth pattern compared to never-smokers (referent). Ex-smokers had a higher score for the traditional pattern compared to never-smokers. Scores for both the fast food and the low vegetable intake patterns did not differ significantly with respect to smoking status in either unadjusted (p=0.680 and p=0.630, respectively) or adjusted models (p= 0.900 and p=0.730, respectively).

The reported associations for dietary patterns were consistent with the differences found for food group intakes with smoking status (data not shown). For example, smokers had lower intakes of fruit, poultry, breakfast cereals, and whole grains, and higher intakes of alcohol, especially beer, than never-smokers.

Table IV shows the analyses of lipid concentrations, antioxidant vitamins, and carotenoids. Total serum cholesterol concentrations differed significantly by smoking status in unadjusted analyses (p=0.003) but this difference disappeared after adjustment for age, alcohol intake, and BMI (p=0.536). High-density lipoprotein (HDL)-cholesterol was lower in heavy-smokers than in ex- and never-smokers. Triglyceride concentrations were higher in ex-, moderate-, and heavy-smokers than in never-smokers. Lipid-standardized vitamin E was found to be unrelated to smoking status (p=0.437), whilst both α- and β-carotene were higher in never- and ex-smokers than heavy-smokers. Serum folate differed by smoking status and was higher in never- and ex-smokers than in heavy-smokers. This difference remained after adjustment for age, BMI, and folate intake, but disappeared after further adjustment for alcohol intake (p=0.123).

Although the above analyses show associations between dietary pattern scores and smoking status, they do not allow any distinction between the methods of dietary pattern analysis (for example, *'a priori'* versus *'a posteriori'*) in terms of the strength of their association with smoking status. In order to address this, a multinomial logistic regression model was used to estimate whether dietary patterns were associated with the likelihood of being an ex-, moderate-, or heavy-smoker (Table V). A higher FVS was associated with a lower risk of being a heavy-smoker, odds ratio (95 % confidence interval), OR (95 %CI) 0.36 (0.53–0.88), and a higher MDS score was associated with a lower risk of being a moderate- or heavy-smoker, OR (95 %CI), 0.84 (0.74–0.95) and 0.69 (0.59–0.81), respectively. The healthy dietary pattern was associated with a lower risk of being a moderate- or heavy-smoker (OR (95 %CI), 0.62 (0.48–0.79) and 0.41 (0.31–0.56), respectively), and the sweet tooth dietary pattern was associated with a reduced risk of being an ex-, moderate-, or heavy-smoker (OR (95 %CI), 0.81 (0.66–0.99), 0.54 (0.42–0.68), and 0.47 (0.35–0.63), respectively). There was evidence that a higher score on the traditional pattern was associated with an increased risk of being an ex-, moderate-, or heavy-smoker, although these did not reach statistical significance. These results are consistent with what was reported in Table III. However, when the PCA-derived dietary patterns were included in the models with the *'a priori'* patterns, there was less evidence of an association with the FVS ($P=0.130$), and the risk estimates for MDS only remained significant for the heavy smokers in which they were attenuated, OR (95 %CI) 0.80 (0.64–0.99 versus 0.69 (0.59–0.81). This suggests that the PCA-derived *'a posteriori'* dietary patterns are more strongly associated with smoking status.

Discussion

Our results highlight significant differences with respect to dietary patterns and smoking status; with smokers, and in particular heavy smokers, having the poorest dietary habits when dietary patterns were examined using both *'a priori'* and *'a posteriori'* approaches. This is consistent with the general observation from the literature that smokers tend to have poorer dietary habits. Smokers have previously been shown to have unhealthy food intake patterns, including consuming fewer fresh fruits and vegetables; therefore, they have lower intake and status of nutrients such as vitamin C, folate, and carotenoids [1, 14, 23, 24]. Many of the differences found between smokers and non-smokers are homogeneous across studies despite variability in dietary habits in different countries [3, 25]. Using comparative approaches to study dietary patterns, this study adds further weight to the argument that smokers may increase their risk of CVD through poorer dietary habits than non-smokers, and this was reflected in their poorer micronutrient and lipid status. We additionally found that dietary supplement use differed significantly by smoking status, with non-smokers having a higher proportion of dietary supplement users than smokers, and this has been shown previously [26–28]. These results, in relation to dietary patterns, support the suggestion that smokers are less health-aware in their lifestyle choices.

However, food choices may not be entirely due to individual preferences because nicotine and other chemicals in cigarettes may also have a direct effect on food choices in smokers, by altering physiological processes relating to smell, taste, or appetite [25, 29]. Therefore, smokers may report a decreased liking for sweet taste after smoking, finding sweet foods, including fruit and fruit juices, less appetizing than savory foods [30, 31].

Ex-smokers more closely resembled never-smokers than current-smokers in terms of their dietary patterns. This increased healthy eating behavior of ex-smokers could reflect a general shift in lifestyle characteristics and behaviors of this group. Ex-smokers, and also never-smokers, have previously been found to have an overall healthier lifestyle and diet than current smokers [13–15, 32, 33]; for example, smokers had low leisure time physical activity, low fruit/vegetable intakes, and high alcohol consumption in comparison to non-smokers, and ex-smokers more closely resembled never-smokers than smokers [13]. The health behaviors of ex-smokers may be associated with time since stopping smoking, but it would seem logical that smoking cessation would be associated with a positive change in other health risk behaviors also.

In terms of study weaknesses, this study was cross-sectional and relatively small; therefore the temporal association between exposure and outcome cannot be established. Smoking status was assigned in response to a self-reported questionnaire, and has not been objectively verified, for example, by assessment of

Table V: Associations between *a 'priori'* and *'a posteriori'* dietary patterns and smoking status.

Dietary pattern	Smoking category	Adjusted for age, BMI, shift-work, and vitamin use[3] OR[1] (95%CI)	p-value[2]	Additionally adjusted for PCA dietary patterns[4] OR[1] (95%CI)	p-value[2]	Additionally adjusted for PCA dietary patterns[5] OR[1] (95%CI)	p-value[2]
Fruit and Vegetable Score	Never smokers	Referent	<0.001	Referent	0.130		
	Ex-smokers	1.07 (0.91, 1.26)		1.32 (1.03, 1.69)			
	Moderate smokers	0.89 (0.72, 1.08)		1.26 (0.93, 1.71)			
	Heavy smokers	0.36 (0.53, 0.88)		1.18 (0.80, 1.72)			
Mediterranean Diet Score	Never smokers	Referent	0.010			Referent	0.020
	Ex-smokers	1.04 (0.94, 1.15)				1.12 (0.97, 1.30)	
	Moderate smokers	0.84 (0.74, 0.95)				0.90 (0.75, 1.07)	
	Heavy smokers	0.69 (0.59, 0.81)				0.80 (0.64, 0.99)	
Healthy	Never smokers	Referent	<0.001	Referent	<0.001	Referent	0.005
	Ex-smokers	0.87 (0.71, 1.06)		0.69 (0.52, 0.92)		0.75 (0.57, 0.99)	
	Moderate smokers	0.62 (0.48, 0.79)		0.51 (0.36, 0.72)		0.71 (0.51, 0.98)	
	Heavy smokers	0.41 (0.31, 0.56)		0.36 (0.24, 0.55)		0.80 (0.64, 0.99)	
Sweet tooth	Never smokers	Referent	<0.001	Referent	<0.001	Referent	<0.001
	Ex-smokers	0.81 (0.66, 0.99)		0.80 (0.66, 0.98)		0.81 (0.67, 1.00)	
	Moderate smokers	0.54 (0.42, 0.68)		0.53 (0.42, 0.68)		0.53 (0.42, 0.68)	
	Heavy smokers	0.47 (0.35, 0.63)		0.47 (0.34, 0.63)		0.46 (0.34, 0.62)	
Low Vegetable Intake	Never smokers	Referent	0.780	Referent	0.430	Referent	0.740
	Ex-smokers	1.11 (0.91, 1.35)		1.19 (0.97, 1.47)		1.12 (0.92, 1.36)	
	Moderate smokers	1.01 (0.79, 1.29)		1.07 (0.83, 1.38)		1.00 (0.78, 1.28)	
	Heavy smokers	1.04 (0.77, 1.42)		1.09 (0.79, 1.50)		1.02 (0.75, 1.40)	
Traditional	Never smokers	Referent	0.030	Referent	0.190	Referent	0.030
	Ex-smokers	1.29 (1.06, 1.56)		1.21 (0.99, 1.48)		1.26 (1.04, 1.54)	
	Moderate smokers	1.26 (1.00, 1.61)		1.20 (0.93, 1.53)		1.30 (1.02, 1.65)	
	Heavy smokers	1.25 (0.93, 1.68)		1.20 (0.89, 1.63)		1.30 (0.97, 1.76)	
Fast food	Never smokers	Referent	0.770	Referent	0.810	Referent	0.620
	Ex-smokers	1.01 (0.83, 1.22)		0.96 (0.78, 1.17)		0.99 (0.81, 1.20)	
	Moderate smokers	1.07 (0.85, 1.36)		1.03 (0.81, 1.31)		1.09 (0.86, 1.38)	
	Heavy smokers	1.15 (0.86, 1.53)		1.12 (0.83, 1.50)		1.19 (0.89, 1.59)	

Moderate smokers defined as <20 cigarettes/day; heavy smokers defined as ≥20 cigarettes/day.
[1] Odds ratio of being an ex-, moderate, or heavy smoker per unit increase in variable.
[2] p-value from likelihood ratio test comparing particular multinomial model including the dietary pattern variable to model excluding the dietary pattern variable.
[3] Estimates for PCA-derived dietary patterns based upon model containing all PCA-derived dietary patterns simultaneously.
[4] Estimates from model containing Fruit and Vegetable Score and PCA-derived dietary patterns, age, BMI, shift-work, and vitamin use.
[5] Estimates from model containing Mediterranean Diet Score and PCA-derived dietary patterns, age, BMI, shift-work, and vitamin use.

serum cotinine levels; smoking prevalence may also be underestimated when based on self-reported data alone [34]. Additionally, data was not collected on social class, although regular shift work was used as a proxy indicator for this variable. As for dietary pattern analysis, we have only looked at a limited number of ways of calculating *'a priori'* patterns, while there are also alternative exploratory statistical methods used to derive *'a posteriori'* dietary patterns, including cluster analysis [6] and reduced rank regression [12]. However, despite the fact that one of the most important issues when conducting dietary pattern analysis is choosing the most appropriate pattern analysis technique, few studies have formally compared these methods, and greater scrutiny of statistical methodology used in deriving dietary patterns is needed [35–41]. Analytic epidemiology is needed within the same cohort to determine dietary patterns and elucidate which procedures yield the best description of the sample or are most predictive of health outcomes [41]. This methodology would enable more robust public health recommendations to be made by determining dietary patterns within specific populations which can help guide successful interventions that can be translated into practice.

Dietary pattern analysis is an alternative approach to examining the dietary differences between smokers and non-smokers because people do not eat isolated nutrients, but rather meals consisting of a variety of foods with complex combinations of nutrients [6]. However, a major limitation of the PCA techniques employed in this study is that results can be sample-specific and affected by subjective analytic decisions, including difficulties in naming the patterns from their factor loadings [42]. Therefore, it may be difficult to define generalizable public health messages from *'a posteriori'* analyses across studies/populations. However, the patterns of food intake in the present study are broadly comparable to those reported elsewhere. In the Nurses' Health Study cohort [43], the two patterns generated were similar to our traditional pattern and FVS. Patterns comparable to our PCA-derived dietary patterns were also found in the EPIC Potsdam study [44]. Similar patterns have also been shown when comparing cluster analysis and PCA techniques [35,39]; therefore these analyses may produce comparable patterns across populations when using different techniques, but this needs to be more firmly established.

Overall, the study of dietary patterns could have important public health implications because messages concerning overall patterns of dietary intake rather than nutrients may be easier for the public to interpret and translate into their own diets. The use of a whole diet approach/dietary patterns has been proposed as a promising alternative and more comprehensive means of studying diet-disease relationships [45]. Few studies have, to date, examined dietary patterns by smoking status, although a recent analysis of the French EPIC cohort found that current smoking was inversely associated with a fruit/vegetables pattern and a processed meat/starchy foods pattern, and positively associated with an alcohol/meat products pattern, these patterns being derived from factor analysis [26]. Also, a PCA-derived Mediterranean diet was found to be positively associated with non-smoking status in a large cohort within the Greek branch of EPIC [39]. Within this current study , we examined both *'a priori'* and *'a posteriori'* dietary patterns, making this study one of the first to formally compare *'a priori'* and *'a posteriori'* dietary patterns in relation to smoking status. In doing so, we have demonstrated that PCA analysis was more closely associated with smoking status. However, the *'a priori'* patterns were also significantly associated with smoking status, even after adjusting for possible confounders. Therefore, whether or not PCA analysis (which requires specialist statistical techniques and may be population-specific) adds value to whole-diet analysis above and beyond *'a priori'* approaches is debatable, if the ultimate aim is to define generalizable public health messages.

In summary, this study is in keeping with the literature in this area which highlights male smokers as a nutritionally vulnerable group. Their less healthy dietary habits are likely to place them at an even greater risk of developing chronic diseases such as CVD along with respiratory diseases and various cancers. We have demonstrated that *'a priori'* and *'a posteriori'* dietary approaches both identified that male smokers, particularly heavy smokers, have less healthy dietary patterns than never or ex-smokers, but that *'a posteriori'* patterns were more closely associated with current (?) smoking status.

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References

1. Palaniappan, U., Jacobs Starkey, L., O'Loughlin, J. and Gray-Donald, K. (2001) Fruit and vegetable consumption is lower and saturated fat intake is higher among Canadians reporting smoking. J. Nutr. 131, 1952–8.

2. Alberg, A. (2002) The influence of cigarette smoking on circulating concentrations of antioxidant micronutrients. Toxicology 180, 121–37.

3. Dallongeville, J., Marecaux, N., Fruchart, J.C. and Amouyel, P. (1998) Cigarette smoking is associated with unhealthy patterns of nutrient intake: a meta-analysis. J. Nutr. 128, 1450–7.

4. Mukamal, K.J. (2006) The effects of smoking and drinking on cardiovascular disease and risk factors. Alcohol Res. Health 29, 199–202.

5. Heitzer, T., Schlinzig, T., Krohn, K., Meinertz, T. and Munzel, T. (2001) Endothelial dysfunction, oxidative stress, and risk of cardiovascular events in patients with coronary artery disease. Circulation 104, 2673–8.

6. Hu, F.B. (2002) Dietary pattern analysis: a new direction in nutritional epidemiology. Curr. Opin. Lipidol. 13, 3–9.

7. Willett, W.C. (1998) Nutritional Epidemiology. Oxford University Press, New York, USA.

8. Patterson, R.E., Haines, P.S. and Popkin, B.M. (1994) Diet quality index: capturing a multidimensional behavior. J Am Diet Assoc. 94, 57–64.

9. Kennedy, E.T., Ohls, J., Carlson, S. and Fleming, K. (1995) The Healthy Eating Index: design and applications. J. Am. Diet. Assoc. 95, 1103–8.

10. Keys, A. (1980) Seven Countries: a Multivariate Analysis of Death and Coronary Heart Disease. Harvard University Press, Massachusetts, USA.

11. Martinez, M.E., Marshall, J.R. and Sechrest, L. (1998) Invited commentary: Factor analysis and the search for objectivity. Am. J. Epidemiol. 148, 17–9.

12. Hoffmann, K., Schulze, M.B., Schienkiewitz, A., Nothlings, U. and Boeing, H. (2004) Application of a new statistical method to derive dietary patterns in nutritional epidemiology. Am. J. Epidemiol. 159, 935–44.

13. Chiolero, A., Wietlisbach, V., Ruffieux, C., Paccaud, F. and Cornuz, J. (2006) Clustering of risk behaviors with cigarette consumption: A population-based survey. Prev. Med. 42, 348–53.

14. Ma, J., Betts, N.M. and Hampl, J.S. (2000) Clustering of lifestyle behaviors: the relationship between cigarette smoking, alcohol consumption, and dietary intake. Am. J. Health Promot. 15, 107–17.

15. Padrao, P., Lunet, N., Santos, A.C. and Barros, H. (2007) Smoking, alcohol, and dietary choices: evidence from the Portuguese National Health Survey. BMC Public Health 3, 138–46.

16. British Heart Foundation (2010) G30NI Northern Ireland CHD statistics 2009–10 [Internet]. Accessed November 2010. Available from http://www.bhf.org.uk/publications/view_publication.aspx?ps=1001139.

17. Yarnell, J.W., Fehily, A.M., Milbank, J.E., Sweetnam, P.M. and Walker, C.L. (1983) A short dietary questionnaire for use in an epidemiological survey: comparison with weighed dietary records. Hum. Nutr. Appl. Nutr. 37, 103–12.

18. Martinez-Gonzalez, M.A., Fernandez-Jarne, E., Serrano-Martinez, M., Wright, M. and Gomez-Gracia, E. (2004) Development of a short dietary intake questionnaire for the quantitative estimation of adherence to a cardioprotective Mediterranean diet. Eur. J. Clin. Nutr. 58,1550–2.

19. Willett, W. and Stampfer, M.J. (1986) Total energy intake: implications for epidemiologic analyses. Am. J. Epidemiol. 124, 17–27.

20. Catignani, G.L., Bieri, J.G. and Driskell, W.J. (1983) Simultaneous determination of retinol and alpha-tocopherol in serum or plasma by liquid chromatography. Clin. Chem. 29, 708–12.

21. Thurnham, D.I., Smith, E. and Flora, P.S. (1988) Concurrent liquid-chromatographic assay of retinol, α-tocopherol, β-carotene, α-carotene, lycopene, and β-cryptoxanthin in plasma, with tocopherol acetate as internal standard. Clin. Chem. 34, 377–81.

22. Hosmer, D.W. and Lemeshow, S. (2000) Applied logistic regression, 2nd edition. Wiley-Interscience Publication, USA.

23. Marangon, K., Herbeth, B., Lecomte, E., Paul-Dauphin, A., Grolier, P., Chancerelle, Y. et al. (1998) Diet, antioxidant status, and smoking habits in French men. Am. J. Clin. Nutr. 67,231–9.

24. Brasche, S., Winkler, G. and Heinrich. J. (1998) Dietary intake and smoking–results from a dietary survey in Erfurt in 1991/92. Z. Ernahrungswiss 37, 211–4.

25. Koh, W.P., Yuan, J.M., Sun, C.L., Lee, H.P. and Yu, M.C. (2005) Middle-aged and older Chinese men and women in Singapore who smoke have less healthy diets and lifestyles than nonsmokers. J. Nutr. 135, 2473–7.

26. Touvier, M., Niravong, M., Volatier, J.L., Lafay, L., Lioret, S., Clavel-Chapelon, F. et al. (2009) Dietary patterns associated with vitamin/mineral supplement use and smoking among women of the E3N-EPIC cohort. Eur. J. Clin. Nutr. 63, 39–47.

27. Reinert, A., Rohrmann, S., Becker, N. and Linseisen; J. (2007) Lifestyle and diet in people using dietary supplements: a German cohort study. Eur. J. Nutr. 46, 165–73.

28. Lyle, B.J., Mares-Perlman, J.A., Klein, B.E., Klein, R. and Greger, J.L. (1998) Supplement users differ from nonusers in demographic, lifestyle, dietary and health characteristics. J. Nutr. 128, 2355–62.

29. Perkins, K.A., Epstein, L.H., Stiller, R.L., Fernstrom, M.H., Sexton, J.E. and Jacob, R.G. (1990) Perception and hedonics of sweet and fat taste in smokers and nonsmokers following nicotine intake. Pharmacol. Biochem. Behav. 35, 671–6.

30. Whichelow, M.J., Golding, J.F. and Treasure, F.P. (1988) Comparison of some dietary habits of smokers and non-smokers. Br. J. Addict. 83,295–304.

31. Redington, K. (1984) Taste differences between cigarette smokers and nonsmokers. Pharmacol. Biochem. Behav. 21, 203–8.

32. Boyle, R.G., O'Connor, P., Pronk, N. and Tan, A. (2000) Health behaviors of smokers, ex-smokers, and never smokers in an HMO. Prev. Med. 31,177–82.

33. Morabia, A., Curtin, F. and Bernstein, M.S. (1999) Effects of smoking and smoking cessation on dietary habits of a Swiss urban population. Eur. J. Clin. Nutr. 53, 239–43.

34. Gorber, S.C., Schofield-Hurwitz, S., Hardt, J., Levasseur, G. and Tremblay, M. (2009) The accuracy of self-reported smoking: A systematic review of the relationship between self-reported and cotinine-assessed smoking status. Nicotine Tob. Res. 11, 12–24.

35. Hearty, A.P. and Gibney, M.J. (2008) Comparison of cluster and principal component analysis techniques to derive dietary patterns in Irish adults. Br. J. Nutr. 101, 598–608.

36. DiBello, J.R., Kraft, P., McGarvey, S.T., Goldberg, R., Campos, H. and Baylin, A. (2008) Comparison of 3 methods for identifying dietary patterns associated with risk of disease. Am. J. Epidemiol. 168, 1433–43.

37. Bailey, R.L., Gutschall, M.D., Mitchell, D.C., Miller, C.K., Lawrence, F.R. and Smiciklas-Wright, H. (2006) Comparative strategies for using cluster analysis to assess dietary patterns. J. Am. Diet. Assoc. 106, 1194–200.

38. Newby, P.K. and Tucker, K.L. (2004) Empirically derived eating patterns using factor or cluster analysis: a review. Nutr. Rev. 62,177–203.

39. Costacou, T., Bamia, C., Ferrari, P., Riboli, E., Trichopoulos, D. and Trichopoulou, A. (2003) Tracing the Mediterranean diet through principal components and cluster analyses in the Greek population. Eur. J. Clin Nutr. 57, 1378–85.

40. Newby, P.K., Muller, D. and Tucker, K.L. (2004) Associations of empirically derived eating patterns with plasma lipid biomarkers: a comparison of factor and cluster analysis methods. Am. J. Clin. Nutr. 80, 759–67.

41. Kant, A.K. (2004) Dietary patterns and health outcomes. J. Am. Diet. Assoc. 104,615–35.

42. Jacques, P.F. and Tucker, K.L. (2001) Are dietary patterns useful for understanding the role of diet in chronic disease? Am. J. Clin. Nutr. 73, 1–2.

43. Adebamowo, C.A., Hu, F.B., Cho, E., Spiegelman, D., Holmes, M.D. and Willett, W.C. (2005) Dietary patterns and the risk of breast cancer. Ann. Epidemiol. 15, 789–95.

44. Schulze, M.B., Hoffmann, K., Kroke, A. and Boeing, H. (2001) Dietary patterns and their association with food and nutrient intake in the European Prospective Investigation into Cancer and Nutrition (EPIC)-Potsdam study. Br. J. Nutr. 85, 363–73.

45. Hu, F.B. and Willett, W.C. (2002) Optimal diets for prevention of coronary heart disease. JAMA 288, 2569–78.

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Appendix 1

Appendix 1: Principal components and factor loadings for dietary variables used in determining *'a posteriori'* dietary patterns using principal components analysis.

	Healthy	Sweet Tooth	Low Veg	Traditional	Fast Food
White bread	–.334*	.016	–.093	–.205	–.018
Brown bread	.280*	.025	–.050	.172	–.188
Wholemeal bread	.432*	–.065	–.096	–.051	–.235
Crispbread	.077	.023	.068	.121	–.016
Sugary cereals	–.006	.418*	.046	–.216	–.004
High fibre cereals	.525*	.175	–.131	.105	–.148
Red meat	–.219	–.094	–.230	.326*	.246
White meat	.390*	.050	.199	–.119	.279*
Processed meat	–.268*	–.009	–.185	.195	.320*
Liver, kidneys	.013	–.127	–.089	.158	.076
White fish	.302*	.012	–.180	–.178	.035
Oily fish	.350*	–.129	.005	–.006	.195
Plain potatoes	.212	.113	–.435*	.300*	.061
Fried potatoes	–.374*	.105	.049	–.034	.368*
Green Veg	.366*	–.075	–.295*	.239*	.353*
Yellow veg	.340*	.019	–.276*	.279*	.351*
Baked beans	.102	.061	–.274*	–.079	.129
Onions	.330*	–.295*	.031	.207	.257*
Spaghetti	.382*	–.120	.226	–.164	.354*
Rice	.419*	–.033	.319*	–.118	.301
Biscuits	.033	.552*	.088	–.150	.004
Chocolate	–.107	.297	.274*	–.211	.278*
Sweets	–.126	.388*	.253*	–.075	.276*
Yoghurt	.413*	.199	.067	.034	–.014
Cake	.163	.409*	–.166	.008	–.010
Milk puddings	.085	.276	–.142	.019	.058
Canned fruit	.111	.283*	–.093	.142	.151
Apples	.445*	.097	–.027	.050	–.111
Pears	.260*	.043	–.133	.150	.008
Oranges	.395*	–.010	–.026	.076	–.083
Bananas	.477*	.153	–.003	–.083	–.083
Eggs	–.257	–.136	–.216	.242	.004
Semi skimmed milk	.314*	.059	–.024	–.441*	–.238
Skimmed milk	.131	–.098	.091	.088	.028
Cream	.225	.090	.182	.287	–.045
Butter	–.167	.023	.046	.168	–.139
PUFA soft margarine	–.031	.017	–.153	–.164	–.209
Other soft margarine	–.202	.050	–.009	.026	.050
Low calorie PUFA soft margarine	.203	–.100	–.033	–.199	.204
Other low calorie soft margarine	.132	.037	.034	.018	–.183
Added sugar	–.193	.282*	–.039	.007	–.096
Fruit juice	.107	.353*	.475*	.467*	–.201
Fizzy drinks	–.090	.405*	.476*	.422*	–.148

Appendix 1

Appendix 1: Principal components and factor loadings for dietary variables used in determining *'a posteriori'* dietary patterns using principal components analysis.

	Healthy	Sweet Tooth	Low Veg	Traditional	Fast Food
White bread	–.334*	.016	–.093	–.205	–.018
Brown bread	.280*	.025	–.050	.172	–.188
Wholemeal bread	.432*	–.065	–.096	–.051	–.235
Crispbread	.077	.023	.068	.121	–.016
Sugary cereals	–.006	.418*	.046	–.216	–.004
High fibre cereals	.525*	.175	–.131	.105	–.148
Red meat	–.219	–.094	–.230	.326*	.246
White meat	.390*	.050	.199	–.119	.279*
Processed meat	–.268*	–.009	–.185	.195	.320*
Liver, kidneys	.013	–.127	–.089	.158	.076
White fish	.302*	.012	–.180	–.178	.035
Oily fish	.350*	–.129	.005	–.006	.195
Plain potatoes	.212	.113	–.435*	.300*	.061
Fried potatoes	–.374*	.105	.049	–.034	.368*
Green Veg	.366*	–.075	–.295*	.239*	.353*
Yellow veg	.340*	.019	–.276*	.279*	.351*
Baked beans	.102	.061	–.274*	–.079	.129
Onions	.330*	–.295*	.031	.207	.257*
Spaghetti	.382*	–.120	.226	–.164	.354*
Rice	.419*	–.033	.319*	–.118	.301
Biscuits	.033	.552*	.088	–.150	.004
Chocolate	–.107	.297	.274*	–.211	.278*
Sweets	–.126	.388*	.253*	–.075	.276*
Yoghurt	.413*	.199	.067	.034	–.014
Cake	.163	.409*	–.166	.008	–.010
Milk puddings	.085	.276	–.142	.019	.058
Canned fruit	.111	.283*	–.093	.142	.151
Apples	.445*	.097	–.027	.050	–.111
Pears	.260*	.043	–.133	.150	.008
Oranges	.395*	–.010	–.026	.076	–.083
Bananas	.477*	.153	–.003	–.083	–.083
Eggs	–.257	–.136	–.216	.242	.004
Semi skimmed milk	.314*	.059	–.024	–.441*	–.238
Skimmed milk	.131	–.098	.091	.088	.023
Cream	.225	.090	.182	.287	–.045
Butter	–.167	.023	.046	.168	–.139
PUFA soft margarine	–.031	.017	–.153	–.164	–.209
Other soft margarine	–.202	.050	–.009	.026	.050
Low calorie PUFA soft margarine	.203	–.100	–.033	–.199	.204
Other low calorie soft margarine	.132	.037	.034	.018	–.183
Added sugar	–.193	.282*	–.039	.007	–.096
Fruit juice	.107	.353*	.475*	.467*	–.201
Fizzy drinks	–.090	.405*	.476*	.422*	–.148

Appendix 1: Continued

	Healthy	Sweet Tooth	Low Veg	Traditional	Fast Food
Squash	–.051	.333*	.149	.227	–.053
Beer	–.106	–.560*	.231	.019	–.062
Wine	.278*	–.350*	.340*	.093	–.083
Sherry	.188	–.137	.293*	.198	–.134
spirits	–.061	–.380*	.119	.252	–.051
Tea	–.080	.211	–.333*	–.070	–.186
Coffee	.009	–.256*	.214	–.060	.183
Crisps	–.151	.014	.414*	–.132	.301*
Ice cream	.033	.401*	.020	–.021	.222
Cheese	.026	–.257*	.154	–.055	–.172
Whole milk	–.419*	.115	–.044	.313*	.093

*Factor loadings >0.25 were considered to be of importance and were used to develop the *'a posteriori'* dietary patterns.

Appendix 1: Continued

	Healthy	Sweet Tooth	Low Veg	Traditional	Fast Food
Squash	–.051	.333*	.149	.227	–.053
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