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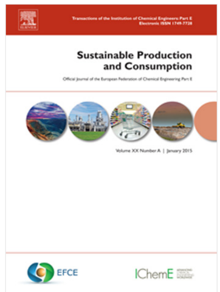

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V. Asvatourian, T. Craig, G.W. Horgan, J. Kyle, J.I. Macdiarmid

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Relationship between pro-environmental attitudes and behaviour and dietary intake patterns

Asvatourian V[1,] Craig T[2], Horgan GW[1], Kyle J[3], Macdiarmid JI[4]

[1] Biomathematics and Statistics Scotland, Aberdeen, UK,
[2] James Hutton Institute, Aberdeen, UK,
[3] Institute of Applied Health Sciences, University of Aberdeen, UK
[4] The Rowett Institute, University of Aberdeen

Corresponding author:
Dr GW Horgan
Biomathematics and Statistics Scotland,
The Rowett Institute,
University of Aberdeen,
Foresterhill
Aberdeen, AB25 2ZD, UK
email: g.horgan@abdn.ac.uk

Abstract

Some of the biggest challenges facing humanity are climate change and future food security, and current dietary patterns are contributing significantly to these problem. While the causes of climate change are known, effective adaption and mitigation will require changing human behaviour and diet. The aim of this study is to explore the link between people's dietary intakes and their behaviour and attitudes to pro-environmental issues. Cluster analysis was used to identify dietary patterns in the sample and principal component analysis used to describe patterns of environmental behaviours and attitudes. Three clusters are identified; *mainstream, health conscious* and *traditional* dietary patterns. The health conscious and mainstream diets are associated with lower GHG emissions than the traditional diet; however this is explained in part by lower energy intakes. Pro-environmental behaviours were more likely to be reported by those with a health conscious diet, but attitudes towards and knowledge of environmental issues did not differ between the three dietary clusters. No association was found between pro-environmental attitudes and behaviours, supporting

the idea that simply raising awareness of these links is unlikely to shift people towards healthy more environmentally sustainable diets needed for future food security.

Highlights

- Three dietary patterns (mainstream, health conscious, traditional) were identified.
- Pro-environmental behaviours were associated with the health conscious diet.
- Pro-environmental attitudes did not differ across the three dietary patterns.
- Energy intake contributed to greenhouse gas emissions more than diet composition.
- Pro-environmental attitudes and behaviours were not strongly associated.

Keywords

Dietary patterns, environmental behaviours, attitudes, greenhouse gas emissions

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Conflict of interest

The authors have no financial or personal conflict of interest to declare.

Authorship

JIM, TC formulated the research questions, JIM, TC, JK designing the study, JIM, TC, JK carrying it out, VA,GH analysed the data, VA, GH, JIM, TC, JK contributed to the interpretation of the results, VA, JIM wrote the manuscript and TC, GH, JK contributed to and revised the manuscript.

1. Introduction

Limiting climate change and reducing the prevalence of diet related disease are major challenges facing nutrition and the wider food system today (Godfray et al., 2010; Tilman and Clark, 2014). Food production is one of the greatest contributors to climate change and the impact is being heightened by our current patterns of food consumption (dietary patterns), which need to change not only for health reasons but also to limit climate change through reducing their contribution to global greenhouse gas (GHG) emissions. In the UK, the food system is estimated to account for 18-20% of total GHG emissions, increasing to approximately 30% when land use change is included (Audsley et al., 2009; Herrero et al., 2016). Unlike some mitigation options associated with behaviours, such as flying, we cannot eliminate food but we can alter the types of diets that we eat. The type and amount of food we eat, can have different levels of environmental impact, with diets high in animal products associated with higher GHG emissions than most plant based diets, and therefore changing dietary patterns can have positive environmental impacts (Eshel et al., 2014; McMichael et al., 2007). While dietary change is an essential element of climate change mitigation it cannot be at the expense of meeting nutritional requirements for health. Since the beginning of the 21st century public awareness of climate change and the environmental damage of non-food related behaviours (e.g. transport, recycling) has increased considerably (Whitmarsh et al., 2011), while in comparison the link to dietary intakes is relatively new but is gaining more attention (Bajželj et al., 2014; Macdiarmid et al., 2016; Watts et al., 2015; Westhoek et al., 2014) . It is not known whether people with pro-environmental attitudes and pro-environmental behaviours are more likely to have more environmentally sustainable diets (e.g. low GHG emissions) and if there is an impact on the nutritional quality of the diet.

When investigating the relationship between behaviours, attitude and dietary intake it is important to distinguish between intent-oriented and impact-oriented behaviours (Stern, 2000) . People, for example, may undertake a particular behaviour with the intention of behaving pro-environmentally, but the environmental impact might actually be relatively low, such as the purchase of organic food (Moser & Kleinhückelkotten, 2018). High impact behaviours however tend to be more difficult to change (e.g. dietary habits), and any adjustments tend to be driven by contextual influences, such as pricing and demographic variables. Interestingly, many studies of pro-environmental behaviour handle food purchasing behaviours alongside recycling and other everyday pro-environmental behaviours that are increasingly seen as being ‘easy’ to achieve (Gatersleben et al., 2002). Gatersleben *et al*. showed that the purchase of what they describe as environmentally friendly food products (e.g. organic) was related to levels of general environmental awareness, but not to demographic factors like income and age as might be expected for an impact-oriented behaviour. It is, however, considerably more complex to choose a combination of food items to make up a nutritionally adequate diet with low GHG emission than to identify single items based on their individual properties.

Dietary habits and food choices should not be viewed as simple behaviours or actions, but rather as a constellation of everyday choices and actions, which, when taken together form a discernible pattern. Therefore dietary patterns are best seen as a domain-specific behavioural pattern as opposed to a singular micro-behaviour. Moreover, there is growing interest in the potential for cross-domain spill over in the field of pro-environmental behaviours (Thøgersen and Ölander, 2003, Thomas, et al, 2016, Truelove, et al , 2014)], and the question of whether measures of environmental attitudes and behaviours are better measured at the domain specific level or at the general level is still an active discussion within the field of environmental psychology (Kaiser et al., 2007, Otto, et al, 2018).

The aim of this study is to identify dietary patterns and their associated GHG emissions, then to explore their relationship, as domain-specific behavioural patterns, with measures of environmental attitudes and behaviours.

The paper is organised as follow: in section 2, we present the questionnaires and the methods we used to investigate the dietary patterns and section 3 presents our results that we discussed in section 4.

2. Materials and Methods

A cross-sectional questionnaire study was conducted in a random sample of 3000 people living in the South West of Scotland in 2010.

2.1 Participants

Three thousand names and addresses (random sample, with one person per household) were purchased from a data consultancy company (ADMAR Ltd, Aberdeen, UK). A postal questionnaire survey, comprising two anonymised questionnaires, was sent out with a freepost envelope in which to return the questionnaire. The first questionnaire assessed habitual dietary intake using a food frequency questionnaire (FFQ) and the second questionnaire was designed to determine environmental attitudes and behaviours. Ethical approval for the study was given by the Rowett

Human Studies Ethical Review Panel (University of Aberdeen). Consent was taken as the return of a completed questionnaire.

2.2 Dietary assessment

Habitual dietary intakes were measured using the semi-quantitative Scottish Collaborative Group food frequency questionnaire (www.foodfrequency.org, version 7.0) (FFQ), validated for dietary assessment among the UK adult population (Jia et al., 2008). It is a research instrument designed to estimate daily intake of a wide range of nutrients in large scale epidemiological studies. This version was developed in Aberdeen, Dundee and Cambridge from the diet questionnaire used in the Scottish Heart Health Study and MONICA study. (Tunstall-Pedoe et al, 2003) Participants reported their frequency of consumption of 170 food and drink items from one of nine options (ranging from 'rarely or never' to 'seven or more times a day') based on the previous two to three months. Questionnaires returned with more than 10 items unreported items were classed as incomplete and not analysed. Nutrient data from UK food composition tables (McCance and Widdowson) are matched to the to the 170 food items in the FFQ and the food, energy and nutrient intake were derived by linking the FFQ response information to an in-house nutrient composition calculation package The estimates of GHG data for each food item was derived from data published by Audsley et al (2010), based on food available in the UK and in this study we adjusted the data to represent food items as eaten to match the format of the nutrient dataset (e.g. cooked rice). These are based not on the full life cycle of food items but, rather, average GHGEs for the production of primary food commodities up to the regional distribution center (RDC). The RDC is described as a nominal boundary of primary production up to the point of distribution which excludes retail, home use and wastage. The 170 food items in the FFQ were categorised into 19 food groups for data analysis, reflecting common nutrient composition of the food items and similar GHG emissions. Full details of the compilation methodology has been described elsewhere for nutrients (Jia et al., 2008) and GHG emissions (Macdiarmid et al., 2012).

2.3 Environmental attitudes and behaviours questionnaire

Self-reported frequency of adopting pro-environmental behaviours was measured by rating 29 statements, based on Kaiser's 50-item general ecological behaviour scale, on a five point scale from 'never' to 'always' (Kaiser and Wilson, 2004). The behaviours include both food and non-food related behaviours and range from behaviours perceived to be very 'easy' (e.g. recycling paper) to behaviours that were felt to be considerably more difficult (e.g. avoiding air travel for long distances). General environmental attitudes were measured using the 15-item 'New Environmental

Paradigm Scale' (NEP) (Dunlap et al., 2000) that has been used in many studies and has proved to have good psychometric properties. Questions asking people about what they thought was the likely impact of various dietary behaviours (e.g. eating meat, fish, dairy) were on the environmental and health were also included in the questionnaire. Participants rated the statements on a five point scale from 'strongly agree' to 'strongly disagree'.

Participants' knowledge of the association between food and impact on health and the environment was assessed. They were asked whether they thought if specific actions would be good for health and would be good for the environment. The questions included changing intakes of specific foods (e.g. meat, dairy, fat, sugar, fish, processed meat, fruit and vegetables) and actions around food (e.g. waste, local food, seasonality, packaging, overconsumption). Socio-demographics characteristics, including age, sex, education, income, self-rated health, locality (rural/urban), employment status, number of cars per house hold, household composition (number of children and people living in the house) were also collected (Gifford and Nilsson, 2014).

2.4 Data analysis

Dietary patterns from reported dietary intakes were identified using cluster analysis, a standard method used in previous studies (Devlin et al., 2012; Hu, 2002; Newby and Tucker, 2004), with each cluster representing a group of individuals who share a similar dietary pattern. Before the analysis was carried out the dataset was standardised to a z-score giving each variable a similar contribution to the analysis, in order to avoid the influence of differences in the weight of foods, such as beverages or energy dense foods. Cluster analysis was then performed on reported dietary intake using two different algorithms: K-means and trimmed K-means clustering (R package trimclust) (Cuesta-Albertos et al., 1997). K-means groups were based on the Euclidean distances between observations (membership to a cluster was dependent on minimizing the distances within clusters and maximizing them between clusters) and trimmed K-means clustering which reduced the impact of outlying observations (Cuesta-Albertos et al., 1997).

Using the K-means algorithm requires the number of clusters to be specified before running. As there is no standard for choosing the number of clusters (Togo et al., 2001) the appropriate final cluster solution was determined using several approaches. First, the structure of the data was investigated by hierarchical clustering (Ward's method) to minimise the sum of square within clusters and then construction of a dendrogram. The plots of the within-cluster sum of squares against the number of clusters (Wirfält and Jeffery, 1997) were examined by running the two different algorithms with a range from 2 to 6 clusters. NbClust function, was used to determine the best number of clusters (Charrad et al., 2014). The final cluster solution was determined by taking into account those that were nutritionally meaningful while keeping a reasonable sample size and avoiding small clusters (Anderson et al., 2010). A three-cluster solution derived from the trimmed K-means was chosen because the solution derived using the K-means method was found to be affected by outliers, which were then reallocated to the closest centre.

The reported food and drink, energy and nutrient intakes differences between clusters were investigated using ANOVA with post hoc testing and the non-parametric Kruskal-Wallis test. Differences in socio-demographic characteristics between the clusters were investigated by using the chi-square test.

Environmental attitudes and behaviour were investigated using a principal component analysis (James et al., 2013) after recoding questions about behaviour and attitudes. Principal component analysis (PCA) is a method used for deriving a low-dimensional set of features from a large set of variables. The aim of PCA is to generate a two-dimensional representation of the data that captures most of the information (variation) in a larger set of variables. Each of the components found by the PCA is a linear combination of the original variables, with the contributions of these variables termed the 'loadings' of the component. The first component is the linear combination which maximises the variance among all representations, the second component maximises the remaining variation etc. Behaviours, were recoded from a five point scale into two categories, "never" or "seldom" (replaced with 0) and "occasionally", "often" or "always" (replaced by 1). Attitudes, were recoded into three numerical categories, "strongly agree" or "agree" (1), "neither agree nor "disagree" (0) or "disagree" and "strongly agree" (-1). The associations between these behaviour and attitudes scores and dietary clusters were assessed using a linear model. These models were adjusted for sex, age, employment status, education, income, cars per household, household composition, rural/urban settings (as suggested by Hu, 2002) by including these as covariate terms in the models.

All analyses were conducted using R (R Core Team, 2015).

3. Results

Of the 3000 households approached 528 (18%) returned the questionnaires and after exclusion of those returning incomplete questionnaires or only one questionnaire, 422 people were included in the analysis.

3.1 Dietary pattern analysis and socio-demographic characteristics

Three distinct dietary clusters were identified and interpreted based on the types and amounts of food consumed as a '*mainstream*' dietary pattern (cluster 1, representing 52.0% of sample population), a '*health conscious*' dietary pattern (cluster 2, representing 25.5% of the population) and '*traditional*' dietary pattern (cluster 3, representing 22.5% of the population). Reported consumption for each food or beverage group for each cluster is shown in Table 1 and the energy and nutrient composition and associated GHG emissions of the dietary pattern in each cluster outlined in Table 2. Naming the clusters will always be debateable, and we considered cluster 2 to be "health conscious" because of its higher intake of fruit, vegetables, breakfast cereals and fish.

Table 1: Reported intakes of foods consumed: a comparison of three dietary patterns.

Reported food intake (g/day)	Mainstream (n=219)		Health conscious (n=108)		Traditional (n=95)		ANOVA p-value ^{y}
	Mean	**CI**	**Mean**	**CI**	**Mean**	**CI**	
Breads	83.7^{a}	[76.5,90.9]	73.5^{b}	[62.5,84.5]	115.0^{c}	[103.3,126.8]	<0.001
Potatoes, rice, pasta	81.9^{a}	[72.5,91.3]	88.3^{a}	[63.2,113.4]	108.3^{b}	[94.3,122.3]	0.023
Breakfast cereals	28.2^{a}	[24.2,32.2]	50.8^{b}	[39.6,62.1]	29.0^{a}	[21.9,36.1]	0.24
Milk	228.9	[199.4,258.6]	223.9	[185.9,261.9]	239.0	[197.17,281.2]	0.76
Yoghurt	53.3^{a}	[44.5,62.1]	90.8^{b}	[71.5,110.24]	49.9^{a}	[35.9,63.8]	<0.001
Cheese	15.3	[12.1,18.4]	12.7	[10.3,15.1]	17.1	[12.9,21.3]	0.44
Eggs	20.0	[17.1,22.9]	21.9	[15.1,28.9]	20.6	[17.0,23.5]	0.71
Meats	66.6^{a}	[62.5,70.6]	56.8^{b}	[50.15,63.5]	115.5^{c}	[102.3,128.6]	<0.001
Fish	67.8^{a}	[62.5,73.3]	113.1^{b}	[98.8,127.2]	88.5^{c}	[73.3,103.8]	<0.001
Vegetarian foods, soups and sauces	74.9^{a}	[69.5,80.2]	124.6^{b}	[110.5,138,9]	115.4^{b}	[100.8,129.9]	<0.001
Vegetables	80.9^{a}	[75.8,86.1]	205.7^{b}	[173.7,237.6]	127.7^{c}	[114.4,140.9]	<0.001
Fruit	162.2^{a}	[145.5,179.1]	349.2^{b}	[304.6,393.8]	210.9^{a}	[168.2,253.7]	<0.001
Puddings,	27.3^{a}	[24.3,30.2]	31.8^{a}	[24.9,38.8]	81.8^{b}	[60.9,102.7]	<0.001
Sweets, chocolates,	22.6^{a}	[19.7,25.5]	20.6^{a}	[16.1,24.1]	42.7^{b}	[34.46,50.9]	<0.001
Nuts, crisps and							
Biscuits	21.8^{a}	[18.7,24.5]	27.4^{a}	[21.9,32.8]	36.6^{b}	[29.5,43.7]	<0.001
Cakes	12.6^{a}	[10.8,14.5]	11.9^{a}	[9.6,14.3]	44.6^{b}	[34.3,54.9]	<0.001
Spreads and sugar$^{¥}$	5.9^{a}	[4.4,7.4]	7.1^{b}	[5.5,8.6]	10.0^{c}	[7.5,12.6]	<0.001
Beverages, soft drinks	1372^{a}	[1289,1455]	1573^{b}	[1456,1690]	1586^{b}	[1454,1718]	<0.01
Alcoholic drinks	118.9	[93.7,144.1]	116.5	[87.9,145.0]	164.3	[102.1,226.4]	0.324

y: analysis of variance
¥ includes fat, jam, chocolate, marmite spreads
Superscripts in common indicate that the means are not significantly different

Total intake of milk, cheese, eggs and alcoholic drinks were similar across the patterns. However, within some of these food groups differences were observed, for example people following a traditional dietary pattern tended to consume full fat versions of dairy products (e.g. cheese, milk, yoghurt) compared to those with a health conscious dietary pattern where more likely to eat lower fat products. People with the traditional dietary pattern were more likely to report higher intakes of beer than those with health conscious diets, who reported drinking wine more frequently. Reported intakes of starchy food (e.g. bread, rice, pasta, potatoes), sweet food (e.g. chocolate, sweet spreads, biscuits, cakes, puddings) and meat were significantly higher in the traditional pattern than those following the other dietary patterns. People with a health conscious dietary pattern reported higher intakes of breakfast cereals (especially muesli, porridge), yoghurt, fish (especially oily fish), vegetables and fruit, soup and sauces (especially beans, lentils, homemade soups) and fruit. While those in the mainstream pattern had lower intakes for most food groups, especially vegetables, fish, than the other clusters.

Table 2: Reported intakes of energy, nutrients and GHG emissions: a comparison of three dietary patterns.

Reported intakes	Mainstream (n=219)		Health conscious (n=108)		Traditional (n=95)		ANOVA p-value ^{z}
Energy & nutrients	**Mean**	**CI**	**Mean**	**CI**	**Mean**	**CI**	
Energy (MJ/d)	6.8^{a}	[6.6-7.1]	8.1^{b}	[7.6-8.6]	10.7^{c}	[10.2-11.2]	<0.001
Carbohydrates (% total energy)	46.9	[46.1-47.8]	47.8	[46.6-49.0]	45.8	[44.6-47.0]	0.067
Total sugars (% total energy)	21.5^{a}	[20.7-22.3]	24.7^{b}	[23.4-26.0]	21.7^{a}	[20.2-22.9]	<0.001
Total fat (% total energy)	33.8^{a}	[33.1-34.7]	33.2^{a}	[32.2-34.2]	37.2^{b}	[36.3-38.1]	<0.001
Saturated fat (% total energy)	13.0^{a}	[12.6-13.4]	11.9^{b}	[11.3-12.5]	15.3^{c}	[14.7-15.9]	<0.001
Protein (% total energy)	15.8^{a}	[15.5-16.1]	16.7^{b}	[16.2-17.2]	14.5^{c}	[14.9-15.1]	<0.001
Protein (g/d)	62.1^{a}	[60.1-64.1]	78.1^{b}	[73.6-82.6]	89.7^{c}	[84.7-94.7]	<0.001
Alcohol (% total energy)	3.2	[2.6-3.8]	3.3	[2.5-4.1]	2.3	[2.6-3.0]	0.162
Fibre (NSP) (g/d)	12.8^{b}	[12.2-13.4]	19.8^{a}	[18.3-21.3]	18.1^{a}	[16.9-19.3]	<0.001
Calcium (mg/d)	870^{b}	[825-914]	1100^{a}	[1188-1012]	1225^{a}	[1149-1301]	<0.001
Iron (mg/d)	10.0^{b}	[9.5-10.5]	13.5^{a}	[12.7-14.3]	14.0^{a}	[13.3-14.7]	<0.001
Zinc (mg/d)	7.2^{a}	[8.9-7.4]	9.3^{b}	[8.6-9.9]	10.8^{c}	[10.1-11.5]	<0.001
Vitamin B6 (mg/d)	1.7^{b}	[1.6-1.8]	2.2^{a}	[2.1-2.3]	2.4^{a}	[2.3-2.5]	<0.001
Vitamin B12 (ug/d)	4.8^{b}	[4.5-5.1]	7.0^{a}	[6.3-7.7]	6.9^{a}	[6.2-7.6]	<0.001
<u>Energy adjusted</u>							
Fibre (NSP) (g/d)	11.8^{a}	[11.4-12.2]	16.6^{b}	[15.6-17.6]	10.6^{a}	[9.6-11.6]	<0.001
Calcium (mg/d)	856^{a}	[820-890]	955^{b}	[895-1015]	829^{a}	[773-885]	0.004
Iron (mg/d)	9.7^{a}	[9.4-10.0]	11.5^{a}	[11.1-11.9]	8.7^{a}	[8.2-9.2]	<0.001
Zinc (mg/d)	7.1^{a}	[6.9-7.3]	7.9^{b}	[7.6-8.2]	6.9^{a}	[6.4-7.4]	<0.001

Reported intakes	Mainstream (n=219)		Health conscious (n=108)		Traditional (n=95)		ANOVA p-value ^{z}
Vitamin B6 (mg/d)	1.6^{a}	[1.5-1.7]	1.9^{b}	[1.8-2.0]	1.5^{a}	[1.4-1.6]	<0.001
Vitamin B12 (ug/d)	4.3^{a}	[4.1-4.5]	5.8^{b}	[5.2-6.4]	4.5^{a}	[3.9-5.1]	<0.001
Greenhouse gas emissions							
GHGE (kgCO_2e/day)	2.4^{a}	[2.3-2.5]	3.2^{b}	[3.1-3.3]	3.6^{c}	[3.5-3.7]	<0.001
GHGE (kgCO_2e/MJ)	0.37^{a}	[0.36-0.38]	0.40^{b}	[0.39-0.41]	0.34^{c}	[0.33-0.35]	<0.001

Superscripts in common indicate that the means are not significantly different
z: analysis of variance, with post hoc multiple comparisons assuming unequal variances

Significantly higher energy intakes were reported by those following a traditional dietary pattern compared with the health conscious and mainstream clusters, with higher proportions of fat and saturated fat in the diet (Table 2). The patterns did not differ for total carbohydrate or alcohol intakes, but the proportion of total sugars in the diet was highest in the health conscious diet, while fibre was lowest in the mainstream diet. However after adjustment for energy intake mainstream and traditional diets consistently reported lower intakes of selected minerals than the health conscious pattern.

The characteristics of people following the different patterns differed by age, sex, income and education (Table 3). Participants following the health conscious dietary pattern tended to be older, compared to the other clusters, and have a higher educational attainment and more likely to be female than those following a traditional dietary pattern. A higher proportion of people with health conscious dietary patterns were retired compared to the mainstream cluster.

Table 3: Socio-demographic characteristics of the participants by dietary cluster.

Characteristics/Cluster	Mainstream (n=219)	Health conscious (n=108)	Traditional (n=95)	P-value[y]
Age (mean (SD))	54.5 (14.7)[a]	62.9 (10.8)[b]	57.1 (17.1)[a]	0.021[z]
Sex (% male)	45	36	55	0.027
Employment (%)				
Full time	37	27	32	0.012
Part time	14	11	11	
Retired	33	55	43	
Unemployed	16	7	14	
Income (%)				
£20,000 or less	43	49	54	0.418
£20,000- £40,000	32	33	29	
over £40,000	25	18	17	
Education (%)				
Secondary school	42	28	60	<0.001
Vocational education	14	12	11	
College (diploma)	23	25	12	
University	21	35	17	
Locality (%, urban/rural)	66 / 34	54 / 46	70 / 30	0.055
Self-rated Health (%)				
Good	57	68	51	0.126
Fairly good	33	24	41	
Not good	10	8	8	
People living in the house (%)				
1	23	22	20	0.905
2	47	52	48	
3	16	15	16	
4 or more	14	11	16	
Children living in the house (%)				
No children	78	90	76	0.121
1 child	11	5	11	
2 or more children	11	5	13	
Cars/household (%)				
No cars	13	9	14	0.133
1	44	59	50	
2 or more	43	32	36	

z: analysis of variance
y: Chi-square test
Superscripts in common indicate that the means are not significantly different

3.2 Dietary patterns and greenhouse gas emissions

The GHG emissions were higher in the traditional diet, which contained more meat than the other clusters but was also higher in energy (Table 2). Figure 1 shows the wide range of GHG emissions associated with the individual dietary patterns and the overlap between the patterns, when expressed in absolute terms (Fig 1a) and when energy adjusted (Fig 1b).

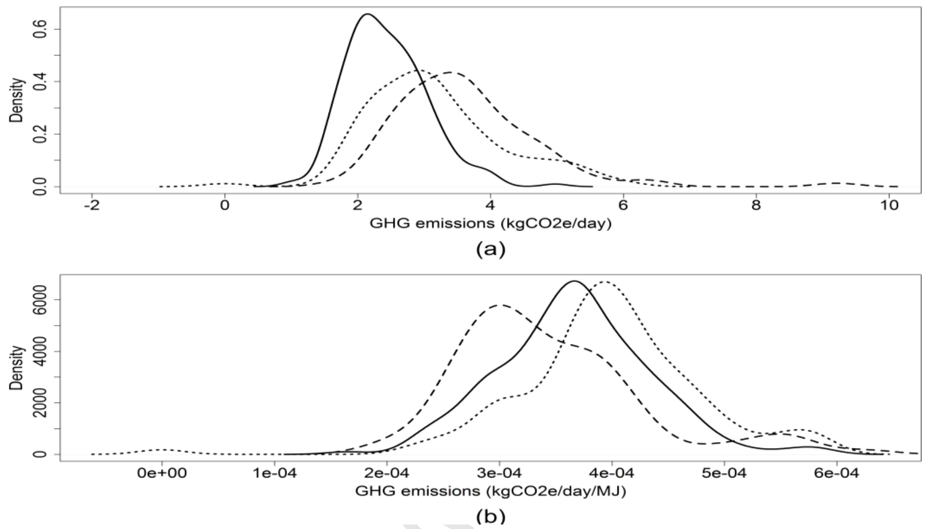

Figure 1: Kernel density estimate of the GHG emissions according to the dietary patterns, expressed as absolute emissions (a) and energy adjusted (per MJ) (b).
Cluster key: solid = mainstream; dotted = health conscious, dashed = traditional.

A positive correlation (r=0.77, p<0.001) was found between the reported energy content of the individual dietary patterns and the associated GHG emissions (Figure 2). Multiple linear regression models between GHG emissions reflecting adjustment of energy associated with the different types of diet are presented in Table 4.

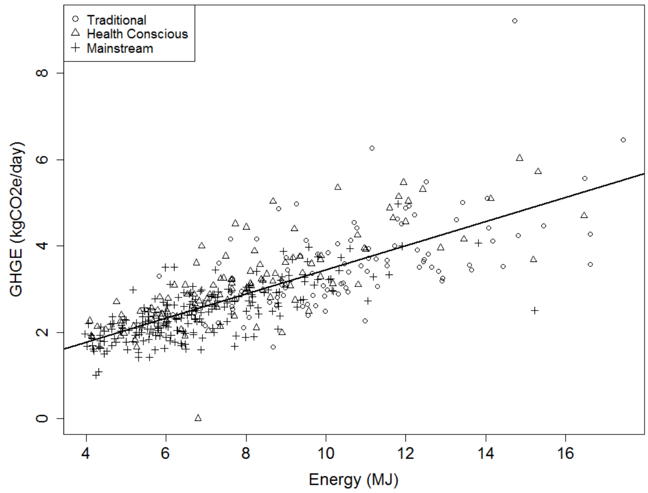

Figure 2: Regression line between reported energy intake and GHG emissions: dietary pattern comparison. Pattern Key: ○ = traditional, Δ = health conscious, + = mainstream.

When compared with the mainstream dietary pattern, adjusting for age and sex but not for the energy content, higher GHG emissions were associated with both the traditional and health conscious patterns and lower GHG emissions associated with the diets of older people and women. When the reported energy intake of the diet was added to the model, the associations with age or sex were no longer significant and the health conscious dietary pattern was found to be associated with higher relative emissions. Also, when looking at the partial R squared, the reported energy intake (R^2=0.48) was found to be contributing more to the explanation of variance in GHG emissions than to the diet pattern (R^2=0.06).

Table 4: Multiple linear regression coefficients for GHG emissions unadjusted (model 1) and adjusted (model 2) for reported energy intake.

	Model 1 (unadjusted GHG emissions)			Model 2 (energy adjusted GHG emissions)		
	Estimate	SE	p-value	Estimate	SE	p-value
Energy intake (MJ)				0.27	0.02	<0.001
Sex						
Men						
Women	-0.19	0.08	0.026	0.01	0.06	0.861
Age	-0.006	0.003	0.039	0.002	0.002	0.302
Dietary pattern						
Mainstream						
Health conscious	0.78	0.1	<0.001	0.32	0.07	<0.001
Traditional	1.14	0.1	<0.001	0.11	0.09	0.235

3.3 Environmental knowledge, behaviours, attitudes and dietary patterns

Participants were aware of the health impacts associated with dietary choices. Over 90% of the participants regarded eating more fish, fruit and vegetables; fewer high fat and high sugar foods; and not overeating as being good for your health. Seventy four percent of the population associated eating less meat with health benefits, but less than 35% of respondents thought that eating less meat would be beneficial for the environment. In general, a small minority people linked dietary changes (i.e. less meat, dairy, overeating) with potential environmental benefits; one exception was eating less fish, which was viewed as being environmentally beneficial by almost 90% of respondents. No differences were observed between the dietary patterns of those people who did, and those that did not see the impact of diets on health or the environment. The majority of people linked environmental benefits with reducing food waste, packaging and buying local and seasonal food.

There was a range of positive and negative responses to both the environmental behaviour and attitudes question, with 72% of responses related to pro-environmental behaviours and 55% related to pro-environmental attitudes. Several behavioural components were identified after PCA analysis, though only the first component was considered meaningful in terms of environmental behaviours and of percentage of variance explained (Table 5). An environmental behaviour pattern on the first component was characterised as an eco-friendly consumerism (i.e. purchasing of eco-friendly products, fruit and vegetables grown in season and organic products), recycling (i.e. paper, glasses), and social behaviour toward conservation (i.e. reading about environmental issues, sustainable diet).

Table 5: Environmental behaviours and their factor loadings grouped into six performance domains.

Behaviour	**Factor loading[a*]** 1st (26.4%)	2nd (10.5%)
Energy conservation		
B2: In the winter, it is warm enough in my house to only wear a t-shirt (r)	0.25	0.04
B3: As the last person to leave a room, I switch off the lights	0.07	0.09
B9: I leave electrically powered appliances on standby (r)	0.32	0.30
B10: I wait until I have a full load before doing my laundry	0.20	-0.11
B23: I take showers rather than baths	0.13	-0.25
B24: In winter, I turn down the heat whenever I leave the house for more than 4 hours	0.27	-0.08
B23: I use a tumble dryer to dry my laundry (r)	0.32	-0.25
Recycling		
B18: I recycle empty plastic bottles	**0.57**	-0.17
B25: I collect and recycle used paper	**0.56**	-0.31
B27: I recycle empty glass bottles	**0.57**	-0.29
Consumerism		
B4: When shopping, I buy eco-friendly products	**0.50**	0.15
B7: I buy fruit and vegetables which are grown locally and in season	**0.46**	-0.02
B14: I buy organic foods	**0.41**	0.10
B22: I use an oven cleaning spray to clean my oven (r)	0.14	0.10
Mobility and transportation		
B8: I choose holiday destinations close to home	0.39	0.16
B11: For short distances (less than 2 miles) I walk or ride a bike	**0.41**	0.24
B16: I drive in such a way as to keep my fuel consumption as low as possible	0.33	**-0.42**
B20: At red traffic lights, I keep the engine running (r)	-0.04	**0.57**
B26: I commute to work by car (r)	0.21	**0.52**
B29: In nearby areas (up to 15 miles) I use public transport or ride a bike	0.19	-0.18
B6: For long journeys in the UK (more than 5 hours by car or train), I take an aeroplane (r)	0.08	0.24
Waste avoidance		
B15: I buy new electronic gadgets whenever I can afford it (r)	0.26	0.10
B28: I reuse my shopping bags	0.31	-0.17
B17: I try to repair items rather than buy new ones	0.36	-0.12
B19: I drink tap water rather than bottled water	0.23	-0.01
B1: If I am offered a plastic bag in a shop or supermarket, I accept it (r)	0.29	0.17
Social behaviour toward conservation		
B21: I read about environmental issues	**0.50**	-0.08
B5:I grow my own fruit and/or vegetables	0.14	-0.24
B12: I choose foods or drinks that I believe to be environmentally friendly	**0.59**	0.15

a: behaviour having a factor loading ≥ |0.40| are highlighted in bold
r: responses were reverse scored
* The loadings are the contribution of that variable to the component score

Different groups of attitudes (as measured by the NEP scale) were identified using PCA (see Table 6). The main attitudes towards environmental issues were characterised by a concern about natural resources (e.g. limit of resources), impact of human activities (e.g. disturbing the balance in nature) and ecological disaster (e.g. fear of an ecological crisis). The first PCA component was used as a measure of environmental attitudes, with a higher loading representing greater concern about environmental issues.

Table 6: Environmental attitudes and their factors loadings grouped into three domains.

Attitudes	Factor loading[a*] 1st (12.4%)	Factor loading[a*] 2nd (6.5%)
Natural resources		
A1: We are approaching the limit of the number of people that the earth can support	**0.55**	-0.26
A6: The earth has plenty of natural resources if we just learn how to develop them (r)	0.39	0.46
A11: The earth has very limited room and resources	**0.50**	-0.14
Human activities		
A2: Humans are severely abusing the environment	**0.65**	-0.28
A3: Human ingenuity will ensure that we do NOT make the earth unliveable (r)	0.41	0.40
A4: When humans interfere with nature it often produces disastrous consequences	**0.50**	-0.35
A5: Humans have the right to modify the natural environment to suit their needs (r)	**0.56**	0.22
A8: The balance of nature is strong enough to cope with the impacts of modern industrial nations (r)	**0.65**	0.20
A9: Despite our special abilities humans are still subject to the laws of nature	0.16	-0.18
Ecological impact		
A10: The so called ‘ecological crisis’ facing human kind has been greatly exaggerated (r)	**0.57**	0.27
A13: The balance of nature is very delicate and easily upset	**0.60**	-0.34
A12: Human were meant to rule over the rest of nature (r)	**0.50**	0.12
A7: Plants and animals have as much right as humans to exist	0.26	-0.40
A14: Humans will eventually learn enough about how nature works to be able to control it (r)	0.36	**0.60**
A15: If things continue on their present course ,we will soon experience a major ecological catastrophe	**0.71**	-0.17

a: attitude having a factor loading ≥ |0.50| are highlighted in bold
r: responses were reverse scored.
* The loadings are the contribution of that variable to the component score

As shown in Table 7, pro-environmental behaviours were significantly associated with being older, having a university degree, lower income and fewer cars per household. Participants with a health conscious dietary pattern had a significantly higher score on the behaviour component (Figure 3a) than people with a mainstream ($p=0.026$) and traditional dietary pattern ($p<0.001$). Positives attitudes to environmental issues were only significantly associated with having a university education and lower income. No significant differences were found between the dietary clusters (Figure 3b).

359 **Table 7:** Multiple linear regression coefficients for environmental behaviour and attitude scores.

Characteristics	Behaviour			Attitudes		
	Estimate	SE	p-value	Estimate	SE	p-value
Sex						
Men	0			0		
Women	0.36	0.22	0.094	$1.6*10^{-3}$	0.25	0.995
Age	0.03	0.01	**0.003**	0.01	0.01	0.349
Dietary pattern						
Mainstream	0			0		
Health conscious	0.86	0.26	**<0.001**	0.51	0.29	0.086
Traditional	0.18	0.26	0.490	-0.04	0.30	0.895
Education						
Secondary school	0			0		
Vocational education	0.76	0.33	0.024	0.30	0.30	0.435
College	0.74	0.27	**0.007**	0.57	0.32	0.071
University	1.09	0.28	**<0.001**	0.92	0.33	**0.005**
Employment						
Unemployed	0			0		
Full time	-0.04	0.33	0.916	0.08	0.38	0.827
Part time	0.26	0.39	0.508	0.27	0.45	0.553
retired	-0.45	0.38	0.247	-0.60	0.44	0.181
Income						
£20,000 or less	0			0		
£20,000-£40,000	-0.19	0.26	0.455	-0.39	0.29	0.187
More than £40,000	-0.69	0.35	**0.047**	-0.84	0.40	**0.037**
Number of cars per household						
No cars	0			0		
1	-0.31	0.34	0.361	-0.21	0.40	0.593
2	-0.45	0.42	0.287	-0.16	0.49	0.738
3 or more	-1.26	0.56	**0.026**	0.40	0.65	0.541
Self-rated health						
Good	0			0		
Fairly good	-0.34	0.22	0.127	0.07	0.26	0.788
Not good	-0.45	0.42	0.290	0.30	0.48	0.544
Number of people living in the house						
1	0			0		
2	0.11	0.29	0.709	0.10	0.34	0.757
3	0.43	0.42	0.306	0.29	0.48	0.544
4 or more	0.52	0.49	0.296	0.13	0.57	0.819
Number of child living in the house						
No children	0					
1	-0.74	0.43	0.086	0.08	0.49	0.879
2 or more	-0.30	0.50	0.554	0.45	0.57	0.438
Locality						
Urban	0			0		
Rural	-0.15	0.22	0.488	0.30	0.25	0.238

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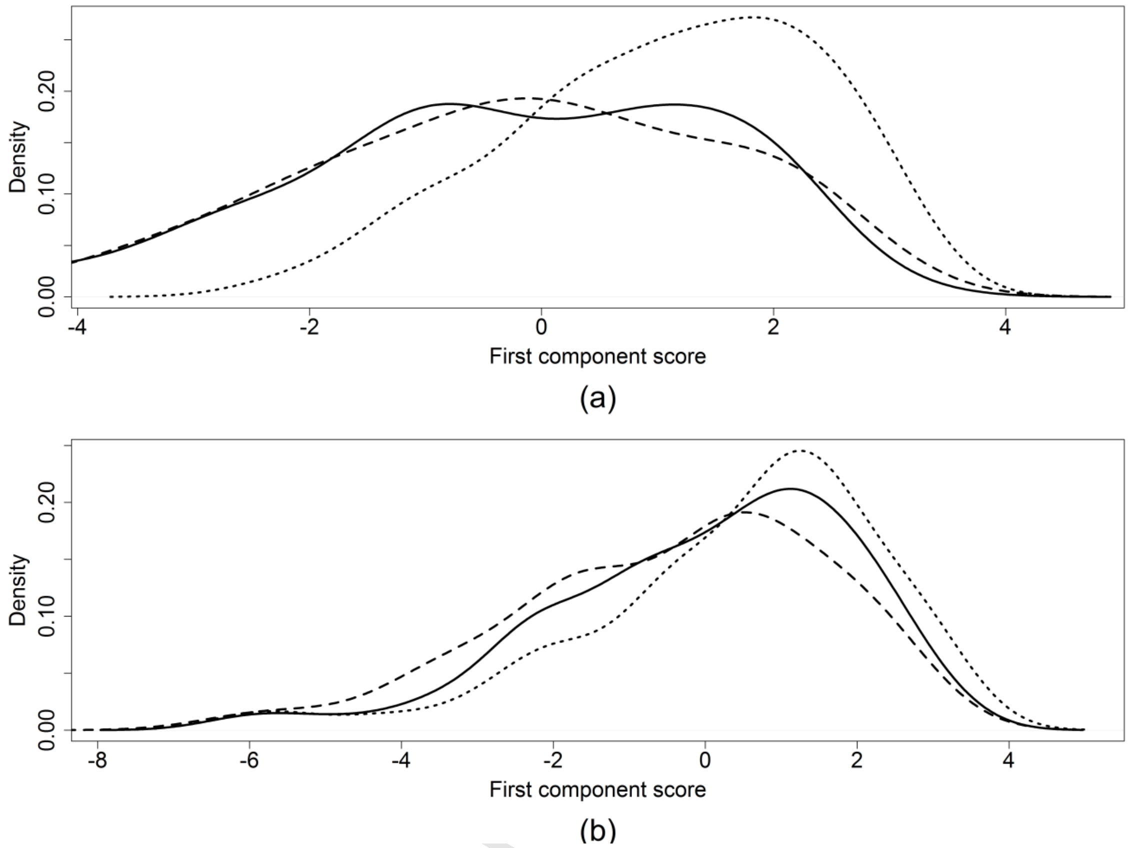

Figure 3: Kernel density estimate of the distribution of scores of (a) environmental behaviours and (b) attitudes according to the dietary patterns. key: Solid = mainstream, dotted = health conscious and dashed = traditional dietary patterns.

3.4 Relation between environmental behaviours and attitudes

There was a small but significant correlation ($r=0.29$, $p<0.001$) between the environmental behaviour and the environmental attitudes component scores. The PCA was repeated to take into account both behaviour and attitudes. Figure 4 shows the contribution that the different questions make to the calculation of the first two components. While some attitudes were shown to be related to some behaviours, most showed that behaviour eigenvectors were approximately perpendicular to the attitudes eigenvectors, indicating that behaviour and attitudes in this study tend to be independent (Figure 4).

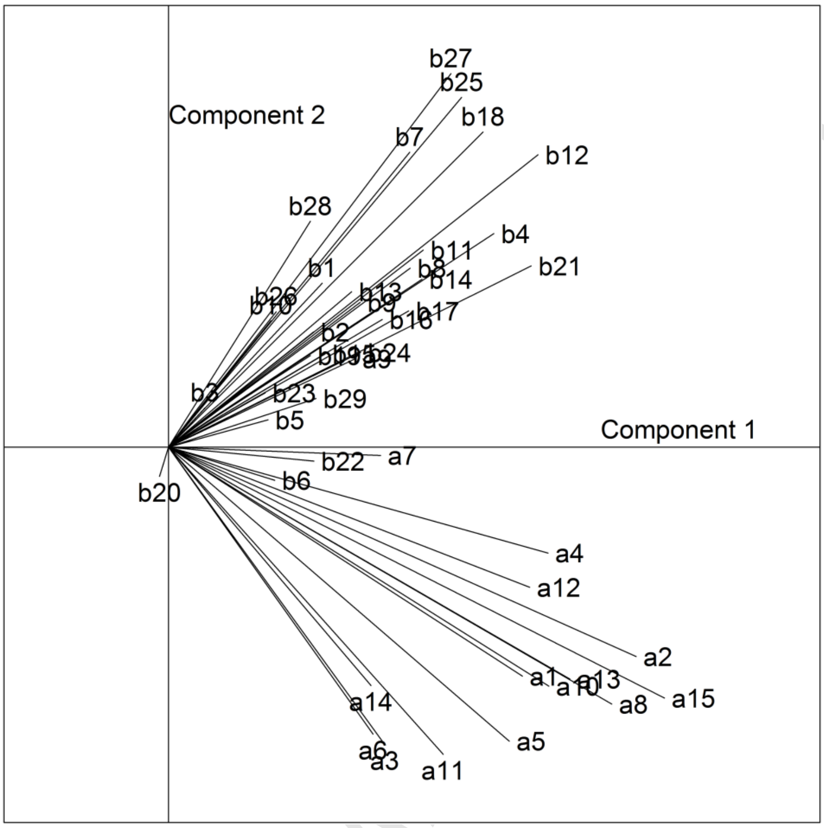

Figure 4: Eigenvectors of the first two components from the PCA taking into account behaviour and attitudes (*a* relates to the attitude questions and *b* to the behaviour questions). See Tables 5 & 6 for the corresponding behaviour and attitude statements.

4 Discussion

In our study, three dietary clusters were identified, mainstream, health conscious and traditional. GHG emissions differed between patterns, in part due to the types of food and beverages consumed, but the variance in emissions was explained more by total energy intake than pattern of intake. An association between reported dietary patterns and pro-environmental behaviours was found, but attitudes and knowledge towards environmental issues did not differ by dietary patterns. Participants with the health conscious dietary pattern were more likely to report pro-environmental behaviours than those in the mainstream and traditional patterns, although the associated GHG emissions of this cluster was not the lowest, and when energy adjusted was higher than the other two clusters.

The dietary patterns identified in this sample are similar to those reported previously in a range of different populations (Devlin et al., 2012; Newby and Tucker, 2004). Commonly reported patterns include those that are considered a *healthy dietary pattern* (health conscious), typically associated with high intakes of fruit and vegetables, while those referred to as a *traditional diet* comprise high intakes of meat, sweet foods and fat. Consistent with the findings of this study, healthy dietary patterns were more common among women, associated with increasing age and higher educational attainment, compared with more traditional dietary patterns that tend to be associated with men and lower educational attainment (Knudsen et al., 2014; Walthouwer et al., 2014). Interestingly in this population, the dietary patterns were not differentiated by income, but those who reported lower incomes were more concerned about environmental issues than those with higher incomes. Previous studies have shown that higher educational attainment is associated with greater concern about environmental issues (Gifford and Nilsson, 2014) and that older women, well-educated participants and those with a higher income are more likely to engage in food related environmental behaviours (Gilg et al., 2005). Knowledge about the environmental impact of food groups in this study population did not differ between clusters and there was no difference in specific behaviours such as buying organic or seasonal products between the dietary patterns groups, but none of the dietary patterns had a clearly lower environmental impact in any case, and we would not necessarily expect this (Macdiarmid, 2003). Future studies might consider more complex models of causality, where any measures of knowledge might be considered as a moderator on particular relationships (such as between attitudes and behaviour). In this way increasing knowledge, even though it is clearly insufficient to directly change dietary behaviours and may be considered as a variable where we would expect a significant interaction with other relationships.

Regarding the link between environmental attitudes and behaviour, recent research has questioned the conceptual separation between attitudes and behaviour, suggesting that general attitudes can be appropriately inferred from behaviours (Kaiser and Byrka, 2015), and that doing so goes some way to reducing the so called value-action gap (Gifford et al., 2011). In general, people associate 'pro-environmental behaviour' with practices such as recycling or energy-efficiency behaviours, which was observed here with the majority of respondents associating food waste, recycling and packaging with environmental impacts and only a minority associating it with the type of foods we eat. Although there is a growing interest in understanding the pathways to more environmentally sustainable diets, there is a scarcity of research explicitly linking psychological variables to dietary patterns in this area. Those who do make the link (Graça et al., 2015) tend not to contextualise diets in the broader portfolio of pro-environmental behaviours familiar to people. In terms of social-representations (Moscovici, 2000), it seems reasonable to say that dietary patterns do not form the centre of the consolation of ideas defining ‘pro-environmental behaviour’. However, the evidence provided in this paper suggests it may be possible to identify subgroups of people in the population whose dietary patterns are indicative of a broader pro-environmental tendency.

Another aspect of the study was to consider the environmental impact of the dietary patterns, using GHG emissions as an indicator of the environmental impact. While in absolute terms the health conscious and mainstream dietary patterns were associated with lower GHG emissions than the traditional dietary pattern this appeared to be driven predominantly by lower reported energy intakes, as seen when the GHG data were expressed relative to energy intake. Energy intake was found to be highly correlated with GHG emissions and moreover, reported energy intake explained more of the variation in GHG emissions than did the dietary clusters. A similar association between total energy intake and GHG emissions was reported in a French population (Vieux et al., 2012). This highlights the need to not just focus on individual food items (e.g. meat) but take into account the whole diet and the total amount of food being eaten when considering dietary change to shift towards healthy sustainable diets. Excessive energy intakes leading to obesity which has serious health implications and therefore, limiting overconsumption could not only limit environmental damage but also address health issues. Furthermore, the range of GHG emissions seen across each dietary cluster suggests that dietary advice around sustainable diets cannot be over simplified by assuming that a single dietary pattern (e.g. healthy diet) would necessarily be associated with lower GHG emissions.

There are some limitations associated with the study. It is widely recognised that all self-reported dietary intakes are subject to misreporting (Devlin et al., 2012; Macdiarmid and Blundell, 1998), with different types of foods likely to be either over or under-reported. Low energy intakes reported in this study may be reflective of some under-reporting, which in part could explain the lower GHG emissions in these clusters. Low reporting is plausible n all clusters. GHG emissions are only one of many environmental issues associated with food production and consumption patterns. The GHG data used in this study does not include emissions from processing, retail and home waste. The population in this study was older than the UK population, but it is representative of the region in which the study was carried out. The response rate of 18% means that the possible existence of other dietary clusters among the non-respondents cannot be excluded. The study population was in a rural area and mean age was over 50. The study has a number of strengths including assessing the composition of the whole diet rather than selecting individual food items in isolation. An advantage of using cluster analysis over other methods to identify dietary patterns is that it produces homogeneous groups where individuals belong to only one cluster, which then can be related to other variables, such as behaviours and attitudes (Devlin et al., 2012).

Given the environmental impact of food choices, especially on climate change, this study provides an important wider perspective of the link between dietary patterns and environmental behaviours and attitudes, exploring whether those with general pro-environmental behaviours and attitudes (many of which are not diet related) are associated with dietary patterns that have a lower environmental impact (e.g. lower in GHG emissions). In this case an association was found between environmental behaviours and dietary patterns but attitudes towards environmental issues did not differ by dietary cluster. These are important observations for understanding how to shift dietary patterns towards diets that are healthier and more environmentally sustainable. Focusing only on increasing knowledge and changing attitudes towards environmental issues is unlikely to influence dietary choices and encourage a shift towards more sustainable diets. Understanding why people decide to undertake food related pro-environmental behaviours (e.g. eating local food, or a diet low in meat) is a non-trivial question, and one which needs further empirical study to unpack these relationships further. Whilst this study examined pro-environmental behaviours at the general level, it would be useful in future studies to explore the interactions between different behavioural domains (for example between waste reduction behaviours and transport related behaviours) as they relate to dietary choices.

Conclusions

We presented one of the first analyses that takes into account diet, behaviour and environmental attitudes in a single study. Even though people have knowledge of environmental issues, they don't necessarily act in accordance with this

In summary this study identified different dietary clusters which varied by energy, nutrient, and GHG emissions. Evidence from this study suggests that pro-environmental behaviours and attitudes tend to be relatively independent and that pro-environmental attitudes and knowledge about the environmental impact of food do not differ between dietary patterns. We should therefore not rely on interventions and policy that simply aim to raise awareness and change attitudes to tackle the significant global problem of climate change and poor dietary intakes.

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