Public Health Nutrition: 16(1), 97–107 doi:10.1017/S1368980012000997

# Maternal dietary patterns and associated nutrient intakes during each trimester of pregnancy

Ciara A McGowan* and Fionnuala M McAuliffe
UCD Obstetrics and Gynaecology, School of Medicine and Medical Science, University College Dublin, National Maternity Hospital, Dublin 2, Ireland

Submitted 22 November 2011: Final revision received 31 January 2012: Accepted 28 February 2012: First published online 12 April 2012

## Abstract

*Objective:* To determine the main dietary patterns of pregnant women during each of the three trimesters of pregnancy and to examine associated nutrient intakes.
*Design:* Participants completed a 3 d food diary during each trimester of pregnancy. Thirty-six food groups were created and dietary patterns were derived using *k*-means cluster analysis.
*Setting:* National Maternity Hospital, Dublin, Ireland.
*Subjects:* Two hundred and eighty-five healthy pregnant women aged between 20 and 41 years.
*Results:* Two dietary patterns were identified at each time point. They were labelled 'Unhealthy' (*n* 143, 150 and 155 at trimester 1, 2 and 3, respectively) and 'Health Conscious' (*n* 142, 135 and 130 at trimester 1, 2 and 3, respectively). Women in the 'Health Conscious' cluster were significantly older, had lower BMI and were higher educated than those in the 'Unhealthy' cluster. Of those in the 'Unhealthy' cluster in the first trimester (*n* 143), 103 (72·0 %) continued in this dietary pattern into trimester 2 and eighty-one (56·6 %) continued into trimester 3. Of those in the 'Health Conscious' cluster in trimester 1 (*n* 142), ninety-five (66·9 %) continued in this dietary pattern into trimester 2 and sixty-nine (48·6 %) continued into trimester 3.
*Conclusions:* Cluster analysis produced two clearly defined dietary patterns at each stage of pregnancy. Knowledge of maternal dietary patterns is important for the development of pregnancy-specific dietary guidelines. Identifying women with an 'Unhealthy' dietary pattern in early pregnancy affords the opportunity for a dietary intervention which may positively impact both maternal and infant health.

**Keywords**
Pregnancy
Dietary pattern
Cluster analysis

The importance of nutrition in pregnancy in promoting an optimal pregnancy outcome is well documented. Deficiencies in intake of energy or specific nutrients during this 'critical period' may have a negative impact on health outcomes in later adult life[1,2]. Pregnancy is therefore a crucial time to identify at risk groups with poor dietary intake and nutritional status in order to deliver appropriate nutrition education.

Nutrition research has traditionally focused on the effects of individual nutrients on disease patterns or pregnancy outcomes. Because nutrients and foods are consumed simultaneously, nutrition researchers are now examining the dietary patterns of populations and their impact on health and disease outcomes[3]. Results from the Dietary Approaches to Stop Hypertension (DASH) intervention study highlighted the importance of studying dietary patterns when they reported that a dietary pattern high in fruits, vegetables, whole grains and low-fat dairy lowered blood pressure more than any individual nutrient found within these foods[4]. Thus, the health effects of the whole dietary pattern may be stronger than that of individual nutrients or foods. Dietary pattern analysis may also help to capture some of the complexity of diets which may be lost during sole nutrient analysis[5]. Understanding the dietary patterns of pregnant women is important for the application of nutritional interventions to improve both maternal and infant health and pregnancy outcomes.

A popular analytical method for assessing the dietary patterns of populations is cluster analysis. Previous research has shown that cluster analysis produces comparable dietary patterns to other analytical methods such as factor analysis when presented with the same data set[6]. Cluster analysis is advantageous as it produces

**Corresponding author:* Email cmcgowa@gmail.com

mutually exclusive clusters with relatively homogeneous dietary patterns. However, the literature is deficient with regard to cluster analysis in pregnancy and particularly with regard to trimester-specific dietary patterns. Nutritional requirements differ throughout pregnancy; for example, folate intake is important in the first trimester and in later trimesters there is more focus on the importance of Fe and Ca[7,8]. The principal aim of the present study was to determine the dietary patterns of pregnant women during the entire pregnancy and during each trimester and to examine whether there were any changes in dietary pattern from early to late pregnancy. Associations with lifestyle characteristics are also examined.

## Methods

### *Participants and setting*

We recruited 398 healthy pregnant women between January 2007 and January 2011 from the antenatal clinic of the National Maternity Hospital, Ireland. Participants included in the study were healthy women, over 18 years of age, not taking any medication, without previous or current gestational diabetes and with adequate English to enable study completion. Eligible women were contacted via telephone by a researcher and invited to attend their first antenatal hospital visit between 10 and 18 weeks' gestation. The study received institutional ethical approval and written informed maternal consent was obtained.

### *Maternal weight and lifestyle characteristics*

At the first antenatal hospital visit participants were weighed using a SECA weighing scale (SECA GmbH & Co. KG, Hamburg, Germany) to the nearest 0·1 kg and height was measured to the nearest 0·1 cm using a wall-mounted stadiometer. BMI was calculated. 'Underweight' was defined as BMI $< 18{\cdot}5\,kg/m^2$[9], 'normal weight' as BMI $= 18{\cdot}5–24{\cdot}9\,kg/m^2$; 'overweight' as BMI $= 25{\cdot}0–29{\cdot}9\,kg/m^2$; and 'obese' as BMI $\geq 30{\cdot}0\,kg/m^2$[10]. Women also completed a questionnaire which asked questions related to their lifestyle such as physical activity, smoking, supplement usage, whether they breast-fed their previous child and education level. Women were also asked questions in relation to general food knowledge; whether they believed they could eat healthier, or if they read food labels. Age and gestational age at their first visit were also recorded.

Participants were deemed physically active based on the number of days per week they took part in moderate-intensity exercise (e.g. brisk walking) for more than 30 min. The American Congress of Obstetricians and Gynaecologists and the Royal College of Obstetricians and Gynaecologists recommend that pregnant women achieve moderate-intensity exercise for 30 min at least 5 d/week[11,12]. If a woman achieved this level she was considered physically active for the purposes of the present analysis.

### *Dietary data and food groups*

Participants did not receive any dietary advice during their pregnancy and were asked not to modify their eating behaviours during the food recording periods. A 3 d food diary was completed during each trimester of pregnancy (trimester 1: 0–14 weeks, trimester 2: 15–28 weeks, and trimester 3: 29–42 weeks' gestation) where the type and amount of all foods and beverages consumed were recorded over three consecutive days. Women were encouraged to include one weekend day during the recording period. Participants were instructed to quantify their food consumed using either the manufacturer's weight on the food packaging or household measures (e.g. tablespoons). If the portion size was not recorded clearly it was quantified by the research dietitian using the average portion sizes according to the Food Standards Agency[13], or in some cases it was estimated by the researcher based on her knowledge of the participant's eating patterns. Dietary data were entered into the dietary analysis software WISP version 3·0[14] (Tinuviel Software, Llanfechell, UK). The food composition tables in WISP are derived from the sixth edition of McCance and Widdowson's food composition tables[15]. The research dietitian was solely responsible for the collection, quantification, coding, and entry and checking of the food diaries. The food diaries were reviewed once weekly to check for errors and to document the quality of the data. If there were any days missing in the food diary this was also documented. The WISP system included an over range check for portion sizes, by generating a warning if a food weight entered was five times more than an average large portion. The research dietitian met with the woman or contacted the woman by telephone if any issues with her food diaries arose. Thirty-five per cent of women were recruited after the first trimester (15–18 weeks); therefore, their first trimester food diary was actually completed in the early weeks of the second trimester.

Seventeen food groups existed in the WISP database at the time of data entry. In order to get a comprehensive depiction of the women's diets and ease the interpretation of analysis, thirty-six food groups were created. When the food file was exported from the WISP database, each food code was manually checked to establish which food group category was most appropriate (see Appendix 1 for a list of the different foods within food groups). The food groups were similar to those used in an Irish national dietary survey[6]. For the cluster analysis food groups were expressed as a percentage of total energy (%TE) as recommended by Hearty and Gibney[6]. All nutrient and food intake results are from food sources alone. A 'food file' containing information from each 3 d food diary completed at each trimester and a 'food file' containing information for all 9 d together (labelled as 'whole pregnancy' food file) were extracted from the WISP database.

### *Identifying the dietary patterns*

Dietary patterns were identified using *k*-means cluster analysis in the statistical software package PASW Statistics version 18·0 (SPSS Inc., Chicago, IL, USA). Prior to running the analysis all food group intakes (%TE) were standardised to a mean of 0 and standard deviation of 1 to remove the extraneous effect of variables with large variances such as beverages. To identify the optimal number of clusters, several runs were conducted varying the number of clusters from two to six. The *k*-means algorithm repeatedly reassigns cases to clusters and each case is finally assigned to the cluster where its distance to the cluster mean is the smallest. Based on these determinations and on the nutritional meaningfulness of the clusters, we selected the two-cluster solution as the most appropriate number. Clusters were checked for outliers and while there was some variability all distances were within reason and any possible outlier was included.

To evaluate the reliability of the dietary patterns, discriminant analysis was performed on the cluster solutions for each trimester of pregnancy and for all trimesters combined. The thirty-six food groups were used as the discriminant variables and the 285 participants as the sample. Classification functions assigned each participant into one of the two clusters. Participants were then cross-classified according to their original cluster membership and the one obtained from the discriminant analysis. Discriminant analysis correctly classified 95·8 % of participants for the whole pregnancy, 97·4 % in trimester 1 and 96·3 % in trimesters 2 and 3. To assess the stability of the clusters *k*-means cluster analysis was carried out in a subset (66·6 %) of participants. For the entire pregnancy 89·0 % of cases were correctly classified by subset analysis, 88·5 % in trimester 1, 95·8 % in trimester 2 and 95·3 % in trimester 3.

### *Statistical analysis*

All statistical analysis was carried out in PASW Statistics version 18·0. Nutrient and food intakes were assessed for normality using the Kolmogorov–Smirnov test. With the exception of vitamins A, C, D, $B_{12}$ and folate all nutrients were normally distributed, therefore nutrient intakes were expressed as means and their standard deviations. Differences in nutrient intakes across clusters and within clusters across trimesters were compared using one-way ANOVA and the Mann–Whitney *U* test for normal and non-normal data, respectively. Except for white breads, vegetables, white meats, processed meats and low-energy beverages all other food intakes were not normally distributed, therefore all food intakes were expressed as medians and interquartile ranges. Differences in food group intakes across clusters were compared using the Mann–Whitney *U* test. The $\chi^2$ test was used to compare categorical variables such as lifestyle habits. To assess compliance to the current recommendations for pregnancy according to Irish and European guidelines[16–18], nutrient variables were categorised into binary variables and were given the value of '1' if a woman met the recommendation (compliant) and '2' if she did not (non-compliant). Differences in levels of compliance between clusters were compared using the $\chi^2$ test. Backward stepwise logistic regression analysis was performed to assess the main predictors of following a 'Health Conscious' dietary pattern at each trimester. The dependent variable was following a 'Health Conscious' pattern at each time point. The independent variables included in the final logistic regression model included maternal age, education level, BMI, ethnicity, previous breast-feeding practices, supplement usage, reading food labels and belief about their health. OR ratios (95 % CI) for the reference groups are presented as 1·00 (–). All results were considered statistically significant if $P < 0·05$.

## Results

Three hundred and seventeen women (80 %) returned their food diaries with 285 women providing three complete food diaries. Table 1 reports the differences in

**Table 1** Differences in baseline characteristics between those who returned complete data and those who did not: healthy pregnant women aged 20–41 years, Dublin, Ireland, January 2007 to January 2011

| | Returned complete 3 d food diaries (*n* 285) | | Did not return complete data (*n* 113) | | |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | *P* |
| Gestation at first antenatal visit (weeks) | 12·8 | 2·3 | 13·2 | 2·4 | 0·214 |
| Weight (kg)† | 72·0 | 12·4 | 76·9 | 15·0 | 0·004 |
| Height (m) | 1·66 | 0·1 | 1·66 | 0·1 | 0·361 |
| BMI (kg/m$^2$)† | 26·3 | 4·2 | 27·9 | 5·7 | 0·018 |
| | *n* | % | *n* | % | |
| Achieved 3rd level education | 149 | 52·3 | 28 | 24·8 | 0·800 |
| Irish Caucasian ethnicity | 245 | 86·0 | 93 | 82·3 | 0·413 |
| Smoker | 7 | 2·5 | 5 | 4·4 | 0·293 |
| Overweight/obese (BMI ≥ 25·0 kg/m$^2$) | 160 | 56·1 | 39 | 34·5 | 0·122 |

Differences between groups were assessed using the independent-samples *t* test for continuous variables and the $\chi^2$ test for categorical variables.
†Variables were log-transformed prior to the analysis as they were not normally distributed.

https://doi.org/10.1017/S1368980012000997 Published online by Cambridge University Press

**Table 2** Maternal lifestyle characteristics and adjusted effect size predicting the likelihood of following a 'Health Conscious' dietary pattern at each trimester: healthy pregnant women (*n* 285) aged 20–41 years, Dublin, Ireland, January 2007 to January 2011

| Trimester 1 | | | Trimester 2 | | | Trimester 3 | | |
|---|---|---|---|---|---|---|---|---|
| Predictor | OR | 95 % CI | Predictor | OR | 95 % CI | Predictor | OR | 95 % CI |
| Age >32 years | 2·19** | 1·26, 3·82 | Education ≥3rd level | 1·78* | 1·06, 3·00 | Age >32 years | 2·94*** | 1·65, 2·22 |
| Age ≤31 years | 1·00 | – | Education ≤2nd level | 1·00 | – | Age ≤31 years | 1·00 | – |
| Non-Irish | 2·71* | 1·19, 6·20 | Non-Irish | 2·38* | 1·11, 5·11 | Non-Irish | 3·52** | 1·52, 8·18 |
| Irish | 1·00 | – | Irish | 1·00 | – | Irish | 1·00 | – |
| Could not be healthier | 3·00* | 1·06, 8·49 | Could not be healthier | 2·28 | 0·86, 6·04 | Takes supplements | 1·96* | 1·12, 3·43 |
| Could be healthier | 1·00 | – | Could be healthier | 1·00 | – | No supplements | 1·00 | – |
| Takes supplements | 2·14** | 1·24, 3·68 | Normal BMI | 1·79* | 1·07, 2·99 | Breast-fed last child | 2·33 | 1·28, 4·25 |
| No supplements | 1·00 | – | Overweight/obese BMI | 1·00 | – | Did not breast-feed | 1·00 | – |
| Breast-fed last child | 1·66 | 0·93, 2·96 | Reads food labels | 1·75 | 0·98, 3·13 | | | |
| Did not breast-feed | 1·00 | – | Does not read food labels | 1·00 | – | | | |

OR (95 % CI) for reference groups are presented as 1·00 and –.
*$P<0·05$, **$P<0·01$, ***$P<0·001$.

baseline characteristics between those who returned complete data and those who did not. Interestingly, those who did not return complete data were significantly heavier in weight and BMI. Thirty women were excluded from the present analysis because they failed to provide sufficient dietary data. Two distinct clusters were found at each trimester and for the whole pregnancy combined. The first cluster was characterised by significantly higher median intakes of white bread, refined breakfast cereals, confectionery, chips, processed meats and high-energy beverages. We named this pattern 'Unhealthy'. The second cluster was characterised by significantly higher intakes of wholegrain breads and breakfast cereals, fruit, vegetables, fruit juice, fish, low-fat milk and white meat. We called this pattern 'Health Conscious'. Women in the 'Health Conscious' clusters at each time point were significantly older (32 years *v.* 30 years, $P<0·001$), weighed less (69 kg *v.* 74 kg, $P=0·001$) and had a lower BMI (25 kg/m$^2$ *v.* 27 kg/m$^2$, $P<0·001$). Table 2 reports the maternal lifestyle characteristics and OR (95 % CI) predicting the likelihood of following a 'Health Conscious' dietary pattern at each trimester. At trimester 1 the strongest predictors of following a 'Health Conscious' dietary pattern were maternal age (>32 years) and if a woman reported taking supplements. At trimester 2 the strongest predictors were maternal BMI (<25·0 kg/m$^2$), education level (≥3rd level) and nationality (non-Irish). Maternal age (>32 years) and if a woman was not native Irish were the strongest predictors in trimester 3. Maternal physical activity, smoking status and whether or not the woman read food labels did not make a significant contribution to the final logistic regression model.

Table 3 shows the median food group intakes within each cluster for the whole pregnancy and Table 4 reports food intakes for each trimester. Forty-nine per cent of women were classified as following a 'Health Conscious' dietary pattern in trimester 1, 47 % in trimester 2 and 46 % in trimester 3. Women following the 'Health Conscious' cluster had consistently higher intakes of wholemeal/grain bread and rolls, fruit and other vegetables at each stage of pregnancy ($P<0·001$), while the women in the 'Unhealthy' cluster had significantly higher intakes of white bread and rolls, refined breakfast cereals, confectionery and high-energy beverages at each stage ($P<0·001$). Tables 5 and 6 report the energy and nutrient profiles of each cluster for the whole pregnancy (Table 5) and at each trimester (Table 6). The 'Health Conscious' cluster was associated with significantly higher intakes of protein (%TE), dietary fibre, vitamins A, C, D, folate, Fe and iodine. Table 5 also reports the levels of compliance with the current recommendations for pregnancy across the clusters. Overall there was greater nutritional adequacy among women in the 'Health Conscious' cluster. However, compliance was low among the total sample for vitamins D, folate, total fat and SFA (%TE).

Of those in the 'Unhealthy' cluster in the first trimester (*n* 143), 103 (72·0 %) continued in this dietary pattern into trimester 2 and eighty-one (56·6 %) continued into trimester 3. Of those in the 'Health Conscious' cluster in trimester 1 (*n* 142), ninety-five (66·9 %) continued in this dietary pattern into trimester 2 and sixty-nine (48·6 %) continued into trimester 3. There were no significant changes in energy or nutrient intakes from trimester 1 to trimester 3 within either cluster. In the 'Unhealthy' cluster there was a significant decrease in the intake of pasta/rice/grains from 77 g/d to 60 g/d ($P=0·024$) and a significant increase in confectionery intake from 14 g/d to 19 g/d ($P=0·031$) from trimester 1 to trimester 3. In the 'Health Conscious' cluster there was a significant increase in biscuits/buns/pastries/cakes from 26 g/d to 35 g/d ($P=0·027$) from trimester 1 to trimester 3 (see Appendix 2 and Appendix 3).

## Discussion

To our knowledge the present study is the first to identify maternal dietary patterns during each stage of pregnancy

**Table 3** Median daily food group intakes for the total sample and across the two dietary patterns identified by cluster analysis throughout pregnancy (three trimesters combined): healthy pregnant women (*n* 285) aged 20–41 years, Dublin, Ireland, January 2007 to January 2011

| | All (*n* 285) | | Dietary pattern: 'Unhealthy' (*n* 124) | | Dietary pattern: 'Health Conscious' (*n* 161) | | |
|---|---|---|---|---|---|---|---|
| Food group (g/d) | Median | IQR | Median | IQR | Median | IQR | *P*† |
| White bread and rolls | 55 | 28–79 | 75 | 58–98 | 35 | 19–58 | <0·001 |
| Brown bread and rolls | 8 | 0–25 | 4 | 0–17 | 14 | 0–31 | 0·001 |
| Wholemeal/grain bread and rolls | 16 | 0–36 | 8 | 0–23 | 23 | 4–61 | <0·001 |
| Pasta/rice/grains | 64 | 38–97 | 59 | 33–86 | 71 | 42–109 | 0·029 |
| Refined breakfast cereals | 10 | 3–20 | 12 | 7–22 | 7 | 0–17 | <0·001 |
| Wholegrain breakfast cereals | 17 | 4–36 | 9 | 0·4–21 | 22 | 7–48 | <0·001 |
| Biscuits/buns/pastries/cakes | 28 | 14–46 | 22 | 11–38 | 32 | 18–52 | <0·001 |
| Savouries | 36 | 12–77 | 40 | 17–74 | 29 | 11–84 | NS |
| Full-fat milk | 56 | 0–147 | 74 | 0·9–174 | 43 | 0–136 | NS |
| Low-fat milks | 28 | 0–133 | 0 | 0–113 | 63 | 0–140 | 0·006 |
| Yoghurts | 20 | 10–31 | 19 | 9–29 | 20 | 11–31 | NS |
| Cheese | 28 | 0–62 | 17 | 0–48 | 42 | 14–69 | <0·001 |
| Cream/ice cream/deserts/puddings | 22 | 7–42 | 18 | 2–35 | 26 | 9–46 | 0·007 |
| Sugars and preserves | 6 | 2–11 | 5 | 1–9 | 7 | 2–12 | 0·008 |
| Confectionery | 13 | 5–22 | 19 | 12–28 | 9 | 3–20 | <0·001 |
| Eggs and egg dishes | 13 | 6–27 | 14 | 6–27 | 13 | 6–27 | NS |
| Butter/full-fat spreads | 6 | 3–10 | 7 | 3–11 | 6 | 3–10 | NS |
| Lower-fat spreads | 0 | 0–2 | 0 | 0–2 | 0 | 0–2 | NS |
| Oils | 0 | 0–2 | 0 | 0–1 | 1 | 0–4 | 0·001 |
| Potatoes | 52 | 27–79 | 39 | 27–68 | 59 | 29–87 | 0·004 |
| Chips | 37 | 18–55 | 49 | 29–73 | 24 | 11–45 | <0·001 |
| Beans/lentils/pulses | 20 | 8–34 | 16 | 7–31 | 23 | 9–35 | 0·045 |
| Other vegetables | 98 | 59–155 | 70 | 43–115 | 124 | 76–174 | <0·001 |
| Fruit | 119 | 62–193 | 71 | 30–108 | 156 | 102–233 | <0·001 |
| Fruit juice | 53 | 11–126 | 40 | 4–77 | 71 | 18–151 | <0·001 |
| White fish and shellfish | 10 | 0–22 | 5 | 0–15 | 13 | 0–27 | <0·001 |
| Oily fish | 0 | 0–6 | 0 | 0–0 | 0 | 0–11 | <0·001 |
| White meat | 43 | 26–64 | 42 | 24–56 | 51 | 26–70 | 0·028 |
| Red meat | 27 | 12–46 | 23 | 11–38 | 28 | 14–47 | NS |
| Other meat/meat products | 34 | 18–49 | 44 | 27–64 | 29 | 14–41 | <0·001 |
| Alcoholic beverages (ml) | 0 | 0–0 | 0 | 0–0 | 0 | 0–0 | NS |
| Savoury snacks | 9 | 3–17 | 11 | 5–20 | 7 | 3–15 | 0·001 |
| Sauces, herbs, spices | 36 | 21–51 | 38 | 23–56 | 34 | 20–47 | NS |
| Soup | 24 | 0–49 | 22 | 0–39 | 24 | 0–56 | 0·015 |
| Low-energy beverage (ml/d) | 844 | 446–1220 | 794 | 447–1142 | 931 | 412–1264 | NS |
| High-energy beverages (ml/d) | 67 | 2–141 | 112 | 42–202 | 49 | 0–100 | <0·001 |

IQR, interquartile range.
Food groups underlined have the greatest difference between the two clusters.
†*P* value assessing the difference in food group intake across the two clusters using the Mann–Whitney *U* test.

using *k*-means cluster analysis. The majority of dietary pattern studies have used factor analysis or principal components analysis (PCA) in identifying their dietary patterns[19–23] and an FFQ as their dietary assessment tool which is usually administered only once in pregnancy. In the present study we used the food diary as our dietary assessment method and this was completed at three times during pregnancy, yielding nine recording days in total. A recent Japanese study also identified dietary patterns using cluster analysis; however, they used an FFQ as their dietary assessment tool and the authors raised concerns over its ability to assess dietary intake[22]. We identified two clearly defined dietary patterns in pregnancy, an 'Unhealthy' pattern and a 'Health Conscious' pattern. There was greater level of compliance to the nutritional recommendations for pregnancy among the 'Health Conscious' cluster. Of concern, vitamin D intakes were particularly low among the total sample which has been previously documented in an Irish pregnant cohort[24].

The Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) cohort study in the UK described five dietary patterns during pregnancy assessed by PCA. They reported a 'Health Conscious' pattern which explained 10·6% of the variance in their dietary data and was associated with higher intakes of brown/wholemeal breads, wholegrain breakfast cereals, fish, cheese, pasta, rice, fruit, fruit juice and salad vegetables[19]. They also found a 'Processed' pattern and a 'Confectionery' pattern which were associated with high intakes of white breads, processed meats and meat products, chips, crisps and confectionery[19]. They found an association with maternal education, age and ethnicity and the 'Health Conscious' pattern. They also found a relationship between the 'Processed' dietary pattern and having a BMI in the overweight category[20]. The Southampton

https://doi.org/10.1017/S1368980012000997 Published online by Cambridge University Press

**Table 4** Median daily food group intakes across the two dietary patterns identified by cluster analysis during each trimester of pregnancy: healthy pregnant women (*n* 285) aged 20–41 years, Dublin, Ireland, January 2007 to January 2011

| | Trimester 1 | | | | Trimester 2 | | | | Trimester 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 'Unhealthy' (*n* 143) | | 'Health Conscious' (*n* 142) | | 'Unhealthy' (*n* 150) | | 'Health Conscious' (*n* 135) | | 'Unhealthy' (*n* 155) | | 'Health Conscious' (*n* 130) | |
| Food group (g/d) | Median | IQR | Median | IQR | Median | IQR | Median | IQR | Median | IQR | Median | IQR |
| White bread and rolls | 73 | 47–105 | 35*** | 9–58 | 71 | 40–98 | 25*** | 0–48 | 71 | 45–105 | 33*** | 10–58 |
| Wholemeal/grain bread and rolls | 0 | 0–24 | 24*** | 0–65 | 0 | 0–24 | 30*** | 0–54 | 0 | 0–24 | 24*** | 0–61 |
| Refined breakfast cereals | 10 | 0–20 | 0** | 0–14 | 10 | 0–20 | 3*** | 0–10 | 17 | 0–30 | 0*** | 0–10 |
| Wholegrain breakfast cereals | 0 | 0–17 | 20*** | 0–53 | 0 | 0–20 | 22*** | 5–53 | 0 | 0–20 | 28*** | 0–56 |
| Biscuits/buns/pastries/cakes | 26 | 0–46 | 18 | 9–43 | 32 | 8–55 | 30 | 10–51 | 23 | 0–43 | 36** | 12–58 |
| Full-fat milks | 67 | 0–166 | 7** | 0–100 | 52 | 0–140 | 28 | 0–125 | 50 | 0–133 | 58 | 0–167 |
| Low-fat milks | 0 | 0–78 | 73*** | 0–160 | 0 | 0–80 | 80** | 0–149 | 0 | 0–137 | 3 | 0–133 |
| Cream/ice cream/deserts/puddings | 0 | 0–40 | 7 | 0–40 | 5 | 0–50 | 23 | 0–58 | 0 | 0–45 | 10 | 0–53 |
| Sugars and preserves | 3 | 0–7 | 7*** | 1–13 | 5 | 0–10 | 6 | 0·3–13 | 5 | 0–12 | 5 | 0–14 |
| Confectionery | 13 | 0–25 | 6** | 0–17 | 17 | 3–31 | 7*** | 0–17 | 18 | 1–35 | 6*** | 0–19 |
| Eggs and egg dishes | 5 | 0–31 | 7 | 0–33 | 0 | 0–20 | 17** | 0–40 | 17 | 0–37 | 12 | 0–40 |
| Butter/full-fat spreads | 7 | 2–12 | 7 | 2–13 | 6 | 2–11 | 6 | 2–12 | 7 | 2–10 | 5 | 2–12 |
| Lower-fat spreads | 0 | 0–0 | 0 | 0–0 | 0 | 0–0 | 0 | 0–0 | 0 | 0–0 | 0 | 0–0 |
| Oils | 0 | 0–0·8 | 0 | 0–4 | 0 | 0–0 | 0*** | 0–4 | 0 | 0–0 | 0*** | 0–4 |
| Potatoes | 40 | 0–60 | 58*** | 15–100 | 40 | 0–58 | 60*** | 27–117 | 40 | 0–73 | 58*** | 40–117 |
| Chips | 55 | 0–78 | 0*** | 0–37 | 55 | 32–88 | 0*** | 0–54 | 55 | 0–83 | 0*** | 0–55 |
| Beans/lentils/pulses | 10 | 0–30 | 20 | 0–40 | 10 | 0–35 | 15** | 0–47 | 10 | 0–33 | 20 | 0–45 |
| Other vegetables | 69 | 34–126 | 117*** | 69–165 | 72 | 32–115 | 131*** | 92–186 | 68 | 40–118 | 128*** | 76–170 |
| Fruit | 80 | 20–138 | 160*** | 100–256 | 67 | 0–133 | 163*** | 100–259 | 80 | 18–133 | 149*** | 80–258 |
| Fruit juice | 52 | 0–137 | 53 | 0–160 | 33 | 0–100 | 53 | 0–136 | 0·3 | 0–106 | 67** | 0–160 |
| White fish and shellfish | 0 | 0–12 | 0** | 0–33 | 0 | 0–28 | 0 | 0–23 | 0 | 0–0 | 0*** | 0–35 |
| Oily fish | 0 | 0–0 | 0 | 0–0 | 0 | 0–0 | 0*** | 0–0 | 0 | 0–0 | 0*** | 0–0 |
| White meat | 43 | 3–73 | 40 | 0–70 | 33 | 0–63 | 60*** | 13–87 | 43 | 9–77 | 43 | 0–78 |
| Other meat/meat products | 33 | 7–56 | 23 | 7–46 | 35 | 17–60 | 22** | 0–49 | 38 | 15–69 | 20*** | 1–42 |
| Soups | 0 | 0–67 | 0** | 0–73 | 0 | 0–65 | 0 | 0–67 | 0 | 0–63 | 0 | 0–68 |
| Low-energy beverages (ml/d) | 889 | 391–1320 | 750 | 443–1257 | 760 | 350–1163 | 980** | 443–1447 | 650 | 380–1085 | 886** | 453–1383 |
| High-energy beverages (ml/d) | 67 | 0–220 | 0*** | 0–83 | 110 | 0–217 | 0*** | 0–67 | 83 | 0–233 | 0*** | 0–67 |

IQR, interquartile range.
Highest median intakes within each cluster are underlined.
*P* value assessing the difference in food group intake across the two clusters during each trimester using the Mann–Whitney *U* test: $^{**}P<0{\cdot}01$, $^{***}P<0{\cdot}001$.

**Table 5** Mean daily energy, macro- and micronutrient intakes and percentage compliance with the current recommendations for pregnancy for the total sample and across the two dietary patterns identified by cluster analysis throughout pregnancy (three trimesters combined): healthy pregnant women (*n* 285) aged 20–41 years, Dublin, Ireland, January 2007 to January 2011

| | | All (*n* 285) | | | Dietary pattern: 'Unhealthy' (*n* 124) | | | Dietary pattern: 'Health Conscious' (*n* 161) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R | Mean | SD | %C | Mean | SD | %C | Mean | SD | %C | *P*† | *P*‡ |
| Energy (MJ) | – | 8·0 | 1·7 | – | 8·0 | 1·9 | – | 8·0 | 1·5 | – | – | – |
| Protein (%TE) | 10–15 | 16·7 | 2·3 | 23·0 | 15·9 | 2·1 | 32·3 | 17·3 | 2·2 | 16·0 | <0·001 | <0·001 |
| CHO (%TE) | ≥55 | 50·1 | 4·9 | 15·0 | 49·9 | 5·2 | 16·1 | 50·3 | 4·7 | 14·1 | NS | NS |
| Total fat (%TE) | <30 | 36·1 | 4·3 | 8·0 | 37·1 | 4·4 | 6·5 | 35·4 | 4·1 | 9·2 | 0·001 | NS |
| SFA (%TE) | <10 | 13·9 | 2·4 | 4·2 | 14·5 | 2·3 | 1·6 | 13·4 | 2·3 | 6·1 | <0·001 | 0·058 |
| PUFA (%TE) | 5–10 | 5·7 | 1·4 | 68·2 | 11·9 | 1·7 | 71·8 | 11·1 | 1·6 | 65·4 | NS | NS |
| MUFA (%TE) | ≤10 | 11·4 | 1·7 | 21·0 | 5·9 | 1·4 | 13·0 | 5·6 | 1·4 | 27·0 | <0·001 | 0·004 |
| Fibre (g) | 20 | 19·0 | 5·4 | 38·3 | 16·4 | 4·8 | 15·3 | 20·9 | 4·9 | 55·8 | <0·001 | <0·001 |
| Vitamin A (RE μg) | 700 | 878·9 | 426·4 | 64·8 | 742·2 | 344·3 | 48·4 | 983·0 | 453·7 | 77·3 | <0·001 | <0·001 |
| Vitamin C (mg) | 80 | 116·4 | 67·8 | 66·2 | 93·1 | 66·5 | 51·6 | 134·1 | 63·4 | 77·3 | <0·001 | <0·001 |
| Vitamin D (μg) | 10 | 2·7 | 1·7 | 0·3 | 2·2 | 1·3 | 0·0 | 3·0 | 1·8 | 0·6 | <0·001 | NS |
| Vitamin $B_{12}$ (μg) | 1·6 | 4·5 | 1·8 | 98·3 | 4·1 | 1·5 | 96·8 | 4·8 | 1·9 | 99·4 | 0·001 | NS |
| Folate (μg) | 500 | 272·3 | 90·7 | 2·1 | 252·0 | 97·5 | 2·4 | 287·7 | 82·2 | 1·8 | <0·001 | NS |
| Ca (mg) | 1200 | 914·3 | 265·7 | 12·2 | 885·9 | 291·0 | 11·3 | 935·9 | 243·4 | 12·9 | NS | NS |
| Fe (mg) | 15 | 11·4 | 3·0 | 12·5 | 10·5 | 2·7 | 7·3 | 12·0 | 3·2 | 16·6 | <0·001 | 0·018 |
| Iodine (μg) | 130 | 136·6 | 51·0 | 50·5 | 125·9 | 48·5 | 41·1 | 144·8 | 51·4 | 57·7 | 0·002 | 0·006 |
| Na (mg) | 2400 | 2702·5 | 642·6 | 31·7 | 2721·2 | 674·7 | 25·8 | 2688·3 | 618·8 | 36·2 | NS | NS |

R, current Irish and European recommendations for pregnant women (Acceptable Macronutrient Distribution Range for macronutrients or the RDA for micronutrients or the population target for dietary fibre and Na)[16–18]; %C, percentage of compliance; %TE, percentage of total energy; CHO, carbohydrate; RE, retinol equivalents.
†*P* value assessing the difference in nutrient intake across the two clusters using one-way ANOVA except for underlined nutrients, which were assessed using the Mann–Whitney *U* test.
‡*P* value assessing the difference in level of compliance to the recommendations for pregnancy across the two clusters using the $\chi^2$ test.

**Table 6** Mean daily energy, macro- and micronutrient intakes across the two dietary patterns identified by cluster analysis during each trimester of pregnancy: healthy pregnant women (*n* 285) aged 20–41 years, Dublin, Ireland, January 2007 to January 2011

| | Trimester 1: 'Unhealthy' (*n* 143) | | Trimester 1: 'Health Conscious' (*n* 142) | | Trimester 2: 'Unhealthy' (*n* 150) | | Trimester 2: 'Health Conscious' (*n* 135) | | Trimester 3: 'Unhealthy' (*n* 155) | | Trimester 3: 'Health Conscious' (*n* 130) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Energy (MJ) | 7·9 | 2·0 | 7·7 | 1·9 | 8·3 | 2·3 | 8·0 | 1·6 | 8·1 | 1·9 | 8·1 | 1·9 |
| Protein (%TE) | 16·4 | 3·1 | 17·3* | 3·0 | 15·8 | 2·6 | 17·8** | 2·9 | 15·8 | 2·9 | 17·7** | 2·8 |
| CHO (%TE) | 49·7 | 6·5 | 51·1* | 6·0 | 49·9 | 6·2 | 50·0 | 5·8 | 50·8 | 6·3 | 49·3 | 5·9 |
| Total Fat (%TE) | 36·8 | 5·3 | 34·6** | 5·4 | 37·2 | 5·5 | 35·1* | 5·3 | 36·3 | 5·4 | 35·8 | 5·3 |
| SFA (%TE) | 14·1 | 2·8 | 13·4* | 3·1 | 14·5 | 3·0 | 13·2** | 2·9 | 14·1 | 3·1 | 13·6 | 3·2 |
| PUFA (%TE) | 6·0 | 2·1 | 5·5* | 2·0 | 5·9 | 1·9 | 5·5 | 1·7 | 5·7 | 1·8 | 5·7 | 1·8 |
| MUFA (%TE) | 11·9 | 2·3 | 10·8** | 2·4 | 11·9 | 2·2 | 10·9** | 2·3 | 11·5 | 2·1 | 11·1 | 2·2 |
| Fibre (g) | 16·5 | 5·6 | 21·3** | 6·2 | 17·1 | 5·6 | 21·5** | 5·7 | 16·8 | 5·2 | 21·3** | 6·5 |
| Vitamin A (RE μg) | 730·1 | 518·1 | 1039·5** | 519·4 | 737·9 | 403·4 | 988·7** | 490·0 | 745·4 | 456·5 | 1073·0** | 944·6 |
| Vitamin C (mg) | 104·4 | 76·1 | 133·6** | 85·3 | 99·4 | 75·1 | 127·3** | 70·5 | 103·6 | 84·2 | 134·4* | 77·5 |
| Vitamin D (μg) | 2·3 | 2·1 | 2·8* | 1·9 | 2·4 | 1·8 | 3·1** | 2·4 | 2·4 | 1·6 | 3·3* | 3·7 |
| Vitamin $B_{12}$ (μg) | 4·0 | 2·0 | 4·6* | 2·2 | 4·2 | 2·1 | 4·6* | 2·0 | 4·2 | 1·9 | 5·4* | 3·9 |
| Folate (μg) | 243·0 | 100·7 | 293·4** | 111·2 | 251·1 | 97·4 | 296·3** | 85·9 | 266·3 | 109·5 | 288·7 | 106·4 |
| Ca (mg) | 835·8 | 290·3 | 952·7 | 324·3 | 906·8 | 316·4 | 931·4 | 281·9 | 896·3 | 304·7 | 971·8* | 355·7 |
| Fe (mg) | 10·8 | 3·6 | 11·8* | 4·0 | 10·7 | 3·2 | 12·1 | 3·5 | 11·1 | 3·3 | 12·0* | 4·1 |
| Iodine (μg) | 119·7 | 60·0 | 140·2* | 63·3 | 132·0 | 67·7 | 148·2* | 64·7 | 127·5 | 61·2 | 155·4* | 76·3 |
| Na (mg) | 2709·2 | 835·5 | 2696·7 | 779·3 | 2750·1 | 775·3 | 2634·3 | 890·1 | 2704·3 | 737·1 | 2703·4 | 888·1 |

%TE, percentage of total energy; CHO, carbohydrate; RE, retinol equivalents.
*P* value assessing the difference in nutrient intake across the two clusters during each trimester using one-way ANOVA except for underlined nutrients, which were assessed using the Mann–Whitney *U* test: **P* < 0·05, ***P* < 0·01, ****P* < 0·001.

Women's Survey (SWS) in the UK employed both PCA and cluster analysis methods in identifying dietary patterns. They identified two patterns using PCA, a 'prudent' diet and a 'high energy' diet. Cluster analysis identified two clusters, a 'healthy' cluster and a 'less healthy' cluster[23]. Our 'Health Conscious' cluster was similar to their 'healthy' cluster with significantly higher intakes of fruit and vegetables, vitamin C, Fe, vitamin $B_{12}$ and folate. The SWS 'less healthy' cluster was comparable to our 'Unhealthy' cluster with higher intakes of white bread,

https://doi.org/10.1017/S1368980012000997 Published online by Cambridge University Press

processed meat, confectionery and high-energy beverages[23]. The Osaka Maternal and Child Health Study in Japan reported three dietary patterns assessed by cluster analysis. Their dietary intakes were, however, quite different from those of our study and previous UK and European studies[22]. They reported intakes of SFA (%TE) as low as 8 %, which is much lower than the mean of 14 % in our study. Intakes of other nutrients such as Ca, Fe and folate were all considerably low and their clusters are therefore not comparable to ours[22]. A Spanish study by Cuco *et al.* examined maternal dietary patterns using a 7 d food diary at four time points during pregnancy in eighty pregnant women[25]. PCA revealed two stable dietary patterns, a 'sweetened beverages and sugars' pattern and a 'vegetables and meat' pattern[25]. Their 'sweetened beverages and sugars' pattern was similar to our 'Unhealthy' pattern and was associated with higher intakes of sugar-sweetened beverages and lower intakes of all fruits and vegetables. The authors concluded that this dietary pattern was negatively associated with lifestyle habits at risk to the health of the pregnant woman and her offspring[25]. Finally, in a non-pregnant Irish population cluster analysis revealed three dietary patterns, 'prudent', 'traditional' and 'alcohol and convenience foods'[26]. Food and nutrient intakes in our 'Health Conscious' cluster closely related to intakes in their 'prudent' cluster. Overall, intakes of macro- and micronutrients between a non-pregnant and pregnant Irish population were comparable[26].

A major strength of the present study is the detailed dietary intake data completed at each stage of pregnancy. One previous study also assessed dietary patterns throughout pregnancy using a 7 d food diary in a much smaller cohort of pregnant women[25]. In our study we used a 3 d food diary which is less labour-intensive than a 7 d food diary and may result in fewer errors like under- or over-reporting of food intake[27]. In the first trimester of pregnancy appetite and dietary intake may be lower due to nausea and vomiting; however, we did not include any woman with reported hyperemesis or severe nausea in our analysis. The women were also healthy women taking no medications and with no known medical conditions. It would be interesting to carry out dietary pattern analysis on this data set using PCA to assess whether PCA and cluster analysis are comparable. A study in 2009 found similar results when its authors employed PCA and cluster analysis on the same data set[6].

## Conclusions

We identified two major dietary patterns in pregnant women using cluster analysis at each stage of pregnancy. We assessed the differences in food and nutrient intakes across clusters as well as examining the nutritional adequacy of each cluster. To our knowledge the present study is the first to identify maternal dietary patterns by cluster analysis during each trimester of pregnancy and to use a detailed food diary as the dietary assessment tool. We also reported on the change in food and nutrient intakes from trimester 1 to trimester 3. Seventy-two per cent of women who followed an 'Unhealthy' dietary pattern in early pregnancy continued this pattern into the second trimester and 56·6 % continued the pattern into the third trimester. Our results would suggest that an 'Unhealthy' dietary pattern tends to persist from early through to late pregnancy. Identification of women with an 'Unhealthy' dietary pattern in early pregnancy therefore affords the opportunity for a dietary intervention which may positively impact both maternal and infant health. Following an 'Unhealthy' dietary pattern during pregnancy may have implications for these women. Results from our logistic regression analysis may suggest that women who engage in healthier behaviours before pregnancy (such as breast-feeding a previous child and taking supplements) maintain a healthy diet into early pregnancy and this lasts until the third trimester. On the other hand, in trimester 2 higher maternal education level was a more important predictor of whether a woman followed a healthy dietary pattern. This indicates that women with a higher level of education may make positive changes to their diets after early pregnancy; however, these changes may not last to the end of pregnancy. Future research is necessary to assess the reasons why women change their dietary behaviours during pregnancy. Women who are younger in age, with lower education level and higher BMI are a potential target group to advise regarding healthy diet during pregnancy.

## Acknowledgements

The work was financially supported by the Health Research Board, Ireland. The authors report no conflict of interest. F.M.M. designed the study. C.A.M. was involved in patient recruitment and was responsible for collection, entry and analysis of the dietary data for the present manuscript. The first draft of the manuscript was written by C.A.M. Both authors contributed to the interpretation of the results and approved the final manuscript. The authors would like to thank the mothers who took part in this study.

## References

1. Barker DJ (1997) Maternal nutrition, fetal nutrition, and disease in later life. *Nutrition* **13**, 807–813.
2. Hanley B, Dijane J, Fewtrell M *et al.* (2010) Metabolic imprinting, programming and epigenetics – a review of present priorities and future opportunities. *Br J Nutr* **104**, Suppl. 1, S1–S25.
3. Jacques PF & Tucker KL (2001) Are dietary patterns useful for understanding the role of diet in chronic disease? *Am J Clin Nutr* **73**, 1–2.

4. Appel LJ, Moore TJ, Obarzanek E *et al.* (1997) A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. *N Engl J Med* **336**, 1117–1124.
5. Newby PK & Tucker KL (2004) Empirically derived eating patterns using factor or cluster analysis: a review. *Nutr Rev* **63**, 177–203.
6. Hearty AP & Gibney MJ (2009) Comparison of cluster and principal components analysis techniques to derive dietary patterns in Irish Adults. *Br J Nutr* **101**, 598–608.
7. Cetin I, Berti C & Calabrese S (2010) Role of micronutrients in the periconceptional period. *Human Reprod Update* **16**, 80–95.
8. Allen LH (2005) Multiple micronutrients in pregnancy and lactation: an overview. *Am J Clin Nutr* **81**, issue 5, 1206S–1212S.
9. World Health Organization/Food and Agriculture Organization of the United Nations (2002) *Report of the Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases*. Geneva: WHO.
10. Institute of Medicine, Committee on Nutrition Status during Pregnancy and Lactation (1990) *Nutrition During Pregnancy*. Washington, DC: National Academy Press.
11. Committee on Obstetric Practice (2002) ACOG committee opinion. Exercise during pregnancy and the postpartum period. Number 267, January 2002. American College of Obstetricians and Gynecologists. *Int J Gynecol Obstet* **77**, 79–81.
12. Royal College of Obstetricians and Gynecologists (2006) Exercise in Pregnancy (RCOG Statement 4). http://www.rcog.org.uk/womens-health/clinicalguidance/exercise-pregnancy (accessed November 2011).
13. Food Standards Agency (2006) *Food Portion Sizes*, 3rd ed. [H Crawley, editor]. London: TSO.
14. Tinuviel Software (2003) *WISP Users Manual. Version 3.0. Intake, Recipe and Menu Nutritional Analysis System*. Warrington: Tinuviel Software.
15. Food Standards Agency (2002) *McCance and Widdowson's The Composition of Foods*, 6th summary ed. Cambridge: Royal Society of Chemistry.
16. Food Safety Authority of Ireland (1999) *Recommended Dietary Allowances for Ireland*. Dublin: Food Safety Authority of Ireland.
17. Eurodiet (2000) Nutrition and Diet for Healthy Lifestyles in Europe. Science and Policy Implications. http://ec.europa.eu/health/archive/ph_determinants/life_style/nutrition/report01_en.pdf (accessed October 2011).
18. Irish Heart Foundation (2007) *Nutrition Guidelines for Heart Health. With Policy Recommendations. May 2007*. Dublin: Irish Heart Foundation.
19. Northstone K, Emmett PM & Rogers I (2008) Dietary patterns in pregnancy and associations with nutrient intakes. *Br J Nutr* **99**, 406–415.
20. Northstone K, Emmett P & Rogers I (2008) Dietary patterns in pregnancy and associations with socio-demographic and lifestyle factors. *Eur J Clin Nutr* **62**, 471–479.
21. Arkkola T, Uusitalo U, Kronberg-Kippila C *et al.* (2008) Seven distinct dietary patterns identified among pregnant Finnish women – associations with nutrient intake and sociodemographic factors. *Public Health Nutr* **11**, 176–182.
22. Okubo H, Miyake Y, Sasaki S *et al.* (2010) Nutritional adequacy of three dietary patterns defined by cluster analysis in 997 pregnant Japanese women: the Osaka Maternal and Child Health Study. *Public Health Nutr* **14**, 611–621.
23. Crozier SR, Robinson SM, Borland SE *et al.* (2006) Dietary patterns in the Southampton Women's Survey. *Eur J Clin Nutr* **60**, 1391–1399.
24. McGowan CA, Byrne J, Walsh J *et al.* (2011) Insufficient vitamin D intakes among pregnant women. *Eur J Clin Nutr* **65**, 1076–1078.
25. Cuco G, Fernandez-Ballart J, Sala J *et al.* (2006) Dietary patterns and associated lifestyle in preconception, pregnancy and postpartum. *Eur J Clin Nutr* **60**, 364–371.
26. Villegas R, Salim A, Collins MM *et al.* (2004) Dietary patterns in middle-aged Irish men and women defined by cluster analysis. *Public Health Nutr* **7**, 1017–1024.
27. Rutishauser IHE (2005) Dietary intake measurements. *Public Health Nutr* **8**, 1100–1107.

## Appendix 1

***The thirty-six food groups considered for identification of the dietary patterns***

| Food group | Foods within each food group |
|---|---|
| White bread and rolls | All breads and rolls made from white flour including French stick, pita, cream crackers, naan bread, ciabatta and chapatti |
| Brown bread and rolls | All breads and rolls made with brown flour including Irish soda bread |
| Wholemeal/grain bread and rolls | All breads and rolls made from wholemeal/wholegrain flours including granary bread, rye bread and wholemeal crackers |
| Pasta/rice/grains | All pasta, rice, noodles and grains (couscous, quinoa, barley, buckwheat, bulgar wheat, cassava, tapioca) and flours (wheat/soya/rice/potato) |
| Refined breakfast cereals | Cornflakes, Rice Krispies, Crunchy Nut Cornflakes, Special K, Frosties, Cocopops, Start, Sugar Puffs, Cereal Bars |
| Wholegrain breakfast cereals | Branflakes, All-Bran, Wheat and Oat bran, Porridge, Oatflakes, Weetabix, Sultana Bran, Fruit'n Fibre, Cheerios, Ready Brek, Mueslis, Shredded Wheat |
| Biscuits/buns/pastries/cakes | All biscuits (digestives, Jaffa cakes), buns (hot cross buns, currant buns), cakes (sponge cake, etc.) and pastries (Danish pastries, croissants, etc.) |
| Cream/ice cream/deserts/puddings | All types of cream, ice cream and deserts and puddings (apple pies, cheesecakes, custard, milkshakes, trifle, banoffee pie, crème caramel, mousse) |
| Full-fat milk | All full-fat cow's/goat's/sheep's/soya/rice milks |
| Low-fat milks | All low-fat and skimmed cow's/goat's/sheep's/soya milks |
| Yoghurts | All yoghurts including full- and low-fat varieties from cow's/goat's milk |
| Cheese | All cheeses (cheddar, mozzarella, brie, camembert, cream cheese, goat's cheese, cheese spreads and processed cheeses) |
| Sugars and preserves | All sugar (white/brown); jams, honey, molasses, treacle, salt and vinegar |
| Confectionery | All sweets, chocolate, chocolate bars and chocolate spreads |
| Eggs and egg dishes | All eggs (chickens/duck/quail) and egg dishes (omelette, quiche, etc.) |
| Butter/full-fat spreads | All butter and spreads that contain >40 % fat |
| Lower-fat spreads | All spreads that contain 40 % fat or less |
| Oils | All oils (vegetable oils, olive oil, coconut oil, etc.) |
| Potatoes | All boiled/baked/mashed potatoes including sweet potato, yam and plantain |
| Chips | All fried/roasted/chipped potatoes including potato wedges, potato cakes, potato fritters, potato waffles, hash browns, potato croquettes |
| Beans/lentils/pulses | All high-protein vegetables including beans, bean products (tofu), lentils, pulses (peas, sweet corn) |
| Other vegetables | All root vegetables (carrots, parsnips) and green leafy vegetables |
| Fruit | All kinds of fruit (fresh/canned/dried) |
| Fruit juice | All kinds of fruit juice, freshly squeezed or bottled |
| White fish and shellfish | White fish and shellfish (cod, haddock, plaice, whiting, canned tuna, crab, mussels, etc.), also includes products like fish pâté and fish paste |
| Oily fish | Oily fish (salmon, trout, mackerel, eel, kipper, sardines, fresh tuna, swordfish, anchovies, herring, etc.) |
| White meat | White meats (chicken, turkey, pork, pheasant, mutton, pigeon) |
| Red meat | Red meats (beef, lamb, deer, duck, goose, rabbit) |
| Other meat/meat products | Processed meats (bacon, ham, sausages, pudding); offal (liver and liver pâté); meat products (nuggets, kebabs, burgers) and meat pies |
| Savoury snacks | Savoury snacks such as potato crisps, popcorn, nuts, seeds, pretzels |
| Sauces, herbs, spices | Herbs (fresh and dried), spices, sauces and dressings (white sauces, pasta sauces, gravy, chutneys, relish) |
| Soup | Soups, broths and consommés |
| Savouries | Savoury dishes (Indian and Chinese dishes, savoury pancakes, stews, casseroles, shepherd's pie, etc.) |
| Alcohol | Includes all alcoholic beverages except non-alcoholic lager |
| Low-energy beverages | Includes water, tea, coffee, sugar free cordials and diet fizzy drinks |
| High-energy beverages | Includes non-diet fizzy drinks, fruit squashes/cordials, hot chocolate, malted drinks made from milk, etc. |

https://doi.org/10.1017/S1368980012000997 Published online by Cambridge University Press

## Appendix 2

### *Mean differences in nutrient intakes within the clusters from trimester 1 to 3*

| | 'Unhealthy' cluster (*n* 81) | | | | 'Health Conscious cluster' (*n* 69) | | | |
|---|---|---|---|---|---|---|---|---|
| | Trimester 1 | Trimester 3 | Difference | *P*† | Trimester 1 | Trimester 3 | Difference | *P*† |
| Energy (MJ) | 7·8 | 8·0 | +0·2 | NS | 7·7 | 8·0 | +0·3 | NS |
| Protein (%TE) | 15·8 | 15·7 | −0·1 | NS | 17·3 | 17·6 | +0·3 | NS |
| CHO (%TE) | 49·9 | 50·3 | +0·4 | NS | 50·4 | 49·5 | −0·9 | NS |
| Total fat (%TE) | 37·1 | 36·9 | −0·2 | NS | 35·2 | 35·7 | +0·5 | NS |
| SFA (%TE) | 14·3 | 14·2 | +0·1 | NS | 13·5 | 13·8 | +0·3 | NS |
| PUFA (%TE) | 6·0 | 5·7 | −0·3 | NS | 5·9 | 5·6 | −0·3 | NS |
| MUFA (%TE) | 11·9 | 11·7 | −0·2 | NS | 11·1 | 11·1 | ↔ | NS |
| Fibre (g) | 16·0 | 16·0 | ↔ | NS | 22·2 | 21·8 | −0·4 | NS |
| Vitamin A (RE μg) | 695·0 | 701·0 | +6·0 | NS | 1057·9 | 1169·9 | +112·0 | NS |
| Vitamin C (mg) | 99·2 | 100·9 | +1·7 | NS | 141·5 | 136·0 | −5·5 | NS |
| Vitamin D (μg) | 2·2 | 2·1 | −0·1 | NS | 2·8 | 3·2 | +0·4 | NS |
| Vitamin $B_{12}$ (μg) | 3·7 | 4·1 | +0·4 | NS | 4·6 | 5·2 | +0·6 | NS |
| Folate (μg) | 235·8 | 250·6 | +14·8 | NS | 293·7 | 297·0 | +3·3 | NS |
| Ca (mg) | 829·4 | 861·2 | +31·8 | NS | 934·8 | 987·4 | +52·6 | NS |
| Fe (mg) | 10·3 | 10·7 | +0·4 | NS | 11·9 | 11·5 | −0·4 | NS |
| Iodine (μg) | 112·2 | 127·3 | +15·1 | NS | 139·3 | 147·8 | +8·5 | NS |
| Na (mg) | 2682·6 | 2715·1 | +32·5 | NS | 2733·4 | 2610·5 | −122·9 | NS |

%TE, percentage of total energy; CHO, carbohydrate; RE, retinol equivalents; ↔, no difference.
†*P* value assessing the difference in nutrient intake from trimester 1 to trimester 3 within each cluster using one-way ANOVA except for underlined nutrients, which were assessed using the Mann–Whitney *U* test.

## Appendix 3

### *Median differences in selected food group intakes (g/d) within the clusters from trimester 1 to 3*

| | 'Unhealthy' cluster (*n* 81) | | | 'Health Conscious' cluster (*n* 69) | | |
|---|---|---|---|---|---|---|
| | Trimester 1 | Trimester 3 | Difference | Trimester 1 | Trimester 3 | Difference |
| White bread and rolls | 81 | 77 | −4 | 29 | 25 | −4 |
| Wholemeal/grain bread and rolls | 0 | 0 | ↔ | 40 | 33 | −7 |
| Pasta/rice/grains | 77 | 60 | −17* | 60 | 60 | ↔ |
| Refined breakfast cereals | 12 | 12 | ↔ | 0 | 0 | ↔ |
| Wholegrain breakfast cereals | 0 | 0 | ↔ | 30 | 37 | +7 |
| Biscuits/buns/pastries/cakes | 18 | 20 | +2 | 26 | 35 | +9* |
| Full-fat milks | 67 | 70 | +3 | 7 | 50 | +43 |
| Low-fat milks | 0 | 0 | ↔ | 67 | 50 | −17 |
| Yoghurts | 13 | 13 | ↔ | 17 | 27 | +10 |
| Cheese | 0 | 0 | ↔ | 42 | 42 | ↔ |
| Cream/ice cream/deserts/puddings | 0 | 0 | ↔ | 13 | 5 | −8 |
| Sugars and preserves | 3 | 5 | +2 | 7 | 6 | −1 |
| Confectionery | 14 | 19 | +5* | 5 | 5 | ↔ |
| Potatoes | 40 | 58 | +18 | 58 | 69 | +11 |
| Chips | 55 | 55 | ↔ | 0 | 0 | ↔ |
| Beans/lentils/pulses | 10 | 10 | ↔ | 20 | 20 | ↔ |
| Other vegetables | 60 | 60 | ↔ | 135 | 128 | −7 |
| Fruit | 67 | 60 | −7 | 161 | 153 | −8 |
| Fruit juice | 33 | 0 | −33 | 53 | 67 | +14 |
| White fish and shellfish | 0 | 0 | ↔ | 0 | 0 | ↔ |
| Oily fish | 0 | 0 | ↔ | 0 | 0 | ↔ |
| White meat | 43 | 43 | ↔ | 43 | 43 | ↔ |
| Red meat | 15 | 0 | −15 | 20 | 30 | +10 |
| Other meat/meat products | 33 | 40 | +7 | 22 | 17 | −5 |
| Soup | 0 | 0 | ↔ | 0 | 0 | ↔ |
| Low-energy beverages | 857 | 650 | −207 | 887 | 886 | −1 |
| High-energy beverages | 110 | 83 | −27 | 0 | 0 | ↔ |

↔, no difference.
*P* value assessing the difference in food group intake from trimester 1 to trimester 3 within each cluster using the Mann–Whitney *U* test: $^*P < 0{\cdot}05$.

https://doi.org/10.1017/S1368980012000997 Published online by Cambridge University Press