Longitudinal comparisons of dietary patterns derived by cluster analysis in 7 to 13 year old children

Kate Northstone[1] PhD

Andrew D.A.C. Smith[1] PhD

P.K. Newby[2,3,4] ScD, MPH, MS

Pauline M. Emmett[1] PhD

[1] School of Social and Community Medicine, University of Bristol

[2] Department of Pediatrics and Program in Graduate Medical Nutrition Sciences, Boston University School of Medicine, 88 East Newton Street, Vose Hall 308, Boston, MA 02188, USA

[3] Department of Epidemiology, Boston University School of Public Health, 88 East Newton Street, Vose Hall 308, Boston, MA 02188, USA

[4] Program in Gastronomy, Culinary Arts, and Wine Studies, Metropolitan College at Boston University, Boston, MA 02215 USA

Corresponding author

Kate Northstone

School of Social and Community Medicine, University of Bristol

Oakfield House, Oakfield Road, Clifton, Bristol, BS8 2BN

United Kingdom

Tel: +44 117 3310040 Fax: +44 117 3310080

Email: Kate.Northstone@bristol.ac.uk

Running title: Longitudinal dietary patterns in children

Abstract

Little is known about changes in dietary patterns over time. This study aims to derive dietary patterns using cluster analysis at 3 ages in children and track these patterns over time. Three-day diet diaries were completed for children from the Avon Longitudinal Study of Parents and Children (ALSPAC) at 7, 10 and 13 years. Children were grouped based on the similarities between average weight consumed (g/day) of 62 food groups using *k*-means cluster analysis. Four clusters were obtained at each age, with very similar patterns being described at each time point: Processed (high consumption of processed foods, chips and soft drinks), Healthy (high consumption of high-fibre bread, fruit, vegetables and water), Traditional (high consumption of meat, potatoes and vegetables) and Packed Lunch (high consumption of white bread, sandwich fillings and snacks). The number of children remaining in the same cluster at different ages was reasonably high: 50% and 43% of children in the Healthy and Processed clusters respectively at age 7 were in the same clusters at age 13. Maternal education was the strongest predictor of remaining in the Healthy cluster at each time point – children whose mothers had the highest level of education were nine times more likely to remain in that cluster compared to those with the lowest. Cluster analysis provides a simple way of examining changes in dietary patterns over time and similar underlying patterns of diet at 3 ages during late childhood, persisted through to early adolescence.

Keywords: dietary patterns, children, cluster analysis, ALSPAC, adolescence, diet diaries, tracking

Introduction

Dietary intake is associated with many health outcomes. When investigating these associations, particularly with health outcomes occurring in adulthood, it is important to consider the effect of diet over the whole life course [1]. Diet may have a cumulative effect and there may be critical periods during which diet is particularly important. In addition the effects of later diet may be influenced or confounded by previous dietary intakes. Therefore longitudinal modeling of the development and change of diet throughout life may be useful, particularly if started during childhood.

Dietary patterns have emerged as an effective way of describing and quantifying diet in nutritional epidemiological studies [2]. These methods recognize that foods and drinks are consumed in combination, and enable study of the whole diet, rather than individual foods or nutrients. Cluster analysis is one such method for deriving dietary patterns, which combines individuals into non-overlapping groups based on similarity of dietary intakes. Meaningful dietary patterns derived using cluster analysis among children have been shown in diverse settings, including Australia [3], Germany [4], Great Britain [5, 6], Finland [7], South Korea [8, 9] and the USA [10, 11]. The majority of these have used data collected from diet diaries, although some used 24 hour recalls [9, 10] and food frequency questionnaires (FFQs) [6].

Despite the diverse cultures represented in the published literature, similar patterns of dietary intake have been identified across studies. Two dichotomous patterns have often been described in adult studies [12-15]: These have been labeled either as ‘prudent’ or ‘healthy’, being related to high intakes of fruit, vegetables, cereals and low-fat dairy products or ‘less healthy’, being related to high intakes of meat, processed meats and added sugar. It is quite likely that an individual’s adult diet is heavily influenced by their childhood diet and it would therefore be important to examine any change in dietary patterns over time prior to adulthood. Such changes, during childhood and from childhood into early adulthood, have been investigated with principal components analysis [16, 17] but we are not aware of any studies that have examined them using dietary patterns obtained from cluster analysis.

Newby and Tucker note that the “reproducibility of patterns over time may either represent instability of the measurements or actual changes in dietary intakes.” [2] It is therefore unclear whether observed changes are due to the underlying patterns themselves changing or whether it is the individuals in that population who are changing their diet over time [17]. Therefore, the purpose of this study is to derive cross-sectional dietary patterns using cluster analysis from diet diary data collected on children between 7 and 13 years of age, and to examine whether these patterns, or the individuals, change over time.

Subjects and Methods

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a population-based birth cohort study investigating environmental, genetic and other influences on development and health [18]. Pregnant women living in the Avon health authority area (South West England) with expected dates of delivery between April 1991 and December 1992, inclusive, were eligible to participate. The current study includes children in the core ALSPAC sample, consisting of 14541 pregnancies together with children from an additional 542 eligible pregnancies that were invited to participate at a later date. There were 14535 children alive at 1 year of age comprising the baseline sample. Further details can be obtained from the ALSPAC website (http://www.bristol.ac.uk/alspac). Ethical approval was obtained from the ALSPAC Law and Ethics Committee and the Local Research Ethics Committees.

Children were invited to attend hands-on research clinics when they were 7, 10 and 13 years of age. The mean age at attendance was 7 years 7 months (s.d. 4 months), 10 years 8 months (s.d. 3 months), and 13 years 10 months (s.d. 2 months) respectively. Prior to each clinic the subjects were sent a 3-day diet diary for care-giver completion at 7 years and child completion at 10 and 13 years, recording all food and drink consumed over two weekdays and one weekend day. During the 10 and 13 years clinics, a nutritionist conducted an interview to clarify portion sizes and any omitted foods and drinks. 24 hour recalls were conducted if the child did not bring a completed diary to the clinic with them (<10% at each time point). Further details on the recording and coding of the dietary data can be found elsewhere [19, 20]; briefly the completed diaries were entered into the DIDO (Diet In Data Out) computer program [21], which generated a weight for every food consumed by each child based on the description given in the diary. For the purposes of this study the average weight of each food consumed over the three days was used. Foods were allocated to 62 groups which were based primarily on the food groups used in FFQs administered to the same subjects [6, 17, 22]; additional groups were included to allow for foods not covered by the FFQ (such as salty flavourings and sauces). The average weights (g/day) consumed in each group were used as input variables for cluster analysis.

Statistical methods

Cluster analysis combines individuals into non-overlapping groups according to the similarity of foods consumed between individuals. Here, similarity between children was measured by the sum of squares of differences in standardized average weights (g/day) of foods consumed in each of the 62 food groups. Cluster solutions are sensitive to extreme values, therefore outliers were removed at that time point (not from other time points, unless they too were outliers); these were defined as children with at least one intake being more than 5 standard deviations higher than the mean, where the mean and standard deviation were calculated from non-zero intakes. The standardization method used was subtraction of the mean and division by the range [23] as there are potential drawbacks of standardization by subtracting the mean and dividing by the standard deviation when performing cluster analysis [24].

The cluster analysis used the *k*-means algorithm, the most common method used in dietary studies [2]. This method minimizes the sum of squares of differences between each child and the mean of his/her cluster. The standard *k*-means algorithm can give incorrect cluster solutions [24] and it was therefore run 100 times, with different starting positions, to find the solution with smallest sum of squares differences. To examine the stability of the final solution, the data were randomly split and analyses performed on separate halves. The number of children allocated to a different cluster gave a measure of stability of the solution. This procedure was repeated five times.

We examined 2- to 6-cluster solutions at each time point: Several factors influenced the choice of the number of clusters to retain, including stability of the cluster solutions, and the size and interpretation of each cluster. At each time point the 4-cluster solution was found to be the most interpretable and was also the most reliable (with less than 10% misclassified at each time point – see results for further details). Analysis of variance (ANOVA) and the Tukey-Kramer method aided interpretation of clusters by testing for differences in the means of each food item according to cluster. We chose to give labels to the clusters to assist with reporting, these labels were subjective and based on the foods that were most highly associated with each cluster. The characteristics of children with dietary data were compared with the whole cohort at baseline using chi-square tests and the following characteristics were considered: child ethnicity (white if both parents were white, non-white otherwise), maternal age at delivery, highest level of maternal education, housing tenure, and whether the mother had ever smoked. These characteristics were reported by the mother via self-completion questionnaires administered during pregnancy. Changes in dietary patterns over time were assessed by cross-tabulating cluster solutions at different ages, and calculating the proportion of children remaining in the same cluster between each pair of ages. A sequence index plot [25] was also used to illustrate the changes in cluster membership over time. Logistic regression was used to assess the associations between the characteristics mentioned above and a child consistently belonging to a particular cluster over time. We chose these variables as we have previously shown that they are associated with dietary patterns cross-sectionally. All analyses were performed in Stata v11.0.

Results

At age 7, 8299 children attended the clinic with 7285 (88%) providing diet diaries. Of these, 6837 (94%) children were available for analysis after outlier removal. At age 10, 7563 children attended, 7473 (99%) provided diaries and 6972 (93%) were available after outlier removal. At age 13, 6147 children attended with 6105 (99%) providing diaries and 5661 (93%) remained after outlier removal. Dietary data was more likely to be available for girls, white children, children with older, higher educated and non-smoking mothers, and those living in homes that were owned or mortgaged. These inequalities were similar across the three ages (data not shown).

A four-cluster solution provided stable clusters with similar interpretations at each age. In stability testing, consisting of five sets of split-sample testing, at most 573 (the maximum from the five sets) children were allocated to different clusters at age 7, at most 460 were reallocated at age 10, and at most 581 were reallocated at age 13. Tables 1- 3 present the sizes of each cluster, and the mean consumption of each food, according to those clusters that were retained at ages 7, 10 and 13 respectively. The mean amount of each food consumed within each cluster differed between ages, generally increasing as the children got older. However, the patterns of foods consumed, and the foods in each cluster with higher and lower than average consumptions, were similar at each age.

The largest cluster at each age, which we chose to label Processed, had higher mean consumption of processed meat, pies and pasties, coated and fried chicken and white fish, pizza, chips, baked beans and tinned pasta, chocolate, sweets, sugar, and diet and regular fizzy drinks compared to the other clusters. The second-largest cluster at each age, which we chose to label Healthy, had higher mean consumption of non-white bread, reduced fat milk, cheese, yoghurt and fromage frais, butter, breakfast cereal, rice, pasta, eggs, fish, vegetable and vegetarian dishes, soup, salad, legumes, fruit, crackers and crispbreads, high energy-density sauces (e.g. mayonnaise), fruit juice, and water. The third cluster had higher mean consumption of red meat, poultry, potatoes, vegetables, flour-based products (e.g. Yorkshire pudding), low energy-density sauces (e.g. gravy), puddings, tea and coffee. This cluster was given the label “Traditional”, in line with a traditional British diet. The final cluster had higher mean consumption of white bread, margarine, ham and bacon, sweet spreads (e.g. honey), salty flavourings (e.g. yeast extract), crisps, biscuits, diet squash, tea and coffee. This cluster was labeled “Packed Lunch”, because in school aged children these foods are often eaten in packed lunches.

Table 4 shows the cluster membership at 10 and 13 years of age tabulated against cluster membership at 7 years. It also shows the proportion of children who remained in each cluster between ages. The highest proportions staying in the same cluster were seen for the Healthy cluster: 54% of children in this cluster at age 7 remained in it at age 10 and 50% were still in it at age 13. Of those in the Healthy cluster at age 10, 50% remained there at age 13. The Processed cluster at age 7 also showed reasonable stability over time: 43% and 46% of children in this cluster at 7 were still in it at 10 and 13 respectively, while 43% in it at 10 remained there at 13. The Traditional and Packed Lunch clusters were less stable with 25% to 34% remaining in those clusters over time. The proportion of children who stayed in the same cluster at all three ages was 20%: for individual clusters the greatest stability was seen for the Healthy cluster 33% with the processed cluster second at 22%. Figure 1 illustrates the tracking of cluster membership over time and shows that the most consistent cluster membership over time was for the Healthy cluster, followed by the Processed cluster.

Given that the Healthy and Processed clusters showed greater stability and could be considered to represent the two extremes of diet we carried out our association analyses on t these clusters only. It can be seen in Table 5 that mothers with the highest level of education had children who were nearly 9 times more likely to be in the Healthy cluster at all 3 time points compared to the lowest level of education (adjusted OR: 8.83 (95%CI: 4.58, 17.01)). This compared to an adjusted OR of 4.39 (95% CI: 3.05, 6.35) for being in the Healthy cluster at any two time points. Girls were also more likely to remain in the Healthy cluster as were children whose mothers were aged over 30 at delivery and who lived in rented/other accommodation. Staying in the processed cluster at all three ages was much more likely in children who were non-white and who had mothers with the lowest levels of education.

Discussion

In this study four meaningful dietary patterns were consistently identified using cluster analysis among children at 7, 10 and 13 years of age: Processed, with higher consumption of processed, convenience and snack foods; Healthy, with higher consumption of high-fibre, low-fat foods, fruit and vegetables; Traditional, with higher consumption of meat and vegetables, and Packed Lunch; with higher consumption of white bread, sandwich fillings, and snacks. Although the mean amounts of each food consumed changed slightly over time, the relative intakes were similar at each age. Therefore the underlying dietary patterns were comparable at the different ages. Although some children changed between clusters at later ages the most stable clusters were the Healthy cluster followed by the Processed cluster and continued membership of both was highly associated with maternal education level (although in opposite directions).

Several studies have extracted dietary patterns in children using cluster analysis, although to our knowledge none have examined longitudinal changes in cluster interpretation or membership. Dietary patterns can be population dependent and the underlying patterns may differ between studies. However, there are many similarities between the patterns we have described here and those in the literature. A study of British children between 1 and 4 years of age identified three clusters [5]. One described a diet with high consumption of prepared meat products, chips and soft drinks, similar to our Processed cluster. A second had a high consumption of wholegrain cereals, low-fat dairy products, fruit and vegetables, similar to our Healthy cluster. The final pattern was identified as a traditional diet and is similar to our Traditional pattern. The lack of a Packed Lunch pattern is most likely due to the children being of a pre-school age. A study of British adults based on 7-day diet diaries found four clusters after stratification by gender [26]. One cluster described a dietary pattern with, in men, high consumption of meat products, chips and beer, and in women, high consumption of convenience foods. A second pattern was identified as a traditional British diet. These are similar to our Processed and Traditional patterns respectively. The remaining two clusters were similar to our Healthy pattern. A study based on an FFQ administered to adults in Ireland [27] found three clusters, a pattern with high consumption of meat products, chips and alcohol, a pattern with high consumption of pasta, rice, brown bread, poultry, fish, fruit and vegetables, and a pattern identified as a traditional Irish diet. These are similar (taking into account cultural differences) to our Processed, Healthy and Traditional patterns respectively. It is also worth noting that a comprehensive review of empirically derived dietary patterns reported that Healthy, Traditional and Less-healthy/Processed patterns were the most commonly reproduced across 54 studies [2].

We have previously extracted three dietary patterns from ALSPAC children at 7 years of age based on FFQ data, using cluster analysis [6]. These patterns described a diet with high consumption of processed foods, a plant-based, and a traditional British pattern. The Packed Lunch pattern was not evident in the FFQ cluster analysis and this is mostly likely explained by the fact that foods typically found in packed lunches were not identified separately in the FFQ. Cluster analysis of the diet diary data, which provides much greater detail in dietary intakes and specific foods consumed, thus provided better separation of foods compared to the FFQ.

Examining cluster membership over time showed that, while children do change their diet, they are more likely to continue following the same dietary pattern as they did at an earlier age: around half of the children continued to follow the same pattern at a later age. This helps to quantify the extent to which dietary patterns are formed in childhood and continue into adolescence, demonstrating that establishing healthy eating habits as early as possible is important. Further research is necessary to quantify the extent to which dietary patterns established in childhood and adolescence are maintained into adulthood. Other studies of British and Irish adults report similar patterns to those observed in this study [12, 15], suggesting that the underlying dietary patterns are similar between children and adults, and healthy or less healthy eating patterns track from childhood. Not surprisingly, children who remained in the Healthy cluster for at least 2 out of the 3 time points were more likely to have higher educated and older mothers. This is similar to the associations we have repeatedly shown with children scoring higher on a ‘Health conscious’ dietary pattern obtained using Principal Components Analysis [22, 28]. The same is true of the processed pattern which by both methods is consistently associated with lower maternal education.

A particular advantage of the current study is the large sample size. While, the sample is biased towards higher socioeconomic status, it also has the advantage of multiple time points that allowed longitudinal examination of the data. Furthermore the dietary data was collected from diet diaries, which are considered to be the gold standard for self-reported dietary assessment. Given we observed some differences in the patterns reported here antd those derived using FFQ data, our next steps are to repeat this study using FFQ data. Similar work in other populations and age groups are needed to better understand the tracking of dietary patterns from a life-course perspective.

Another popular method of obtaining dietary patterns is principal components analysis (PCA). However, cluster analysis has a potential advantage over PCA when examining longitudinal changes in dietary patterns. Specifically, while both methods can identify changes in the underlying patterns, cluster analysis can more clearly demonstrate dietary changes within individuals even when the patterns themselves change over time. For example, it is highly likely in the ALSPAC population that the Packed Lunch pattern will not persist into adulthood. Using cluster analysis we will be able to identify what happens to the diet of those young adults who belonged to the Packed Lunch cluster in childhood. As far as we are aware, this is the only example of a longitudinal study which has examined dietary patterns over time using cluster analysis. The tracking of childhood diets may be an important factor in the development of adult-onset disease and we intend to perform a similar analysis on the dietary patterns obtained using PCA. Such additional studies are needed to continue moving the literature forward.

Acknowledgements

We are extremely grateful to all the families who took part in this study, the midwives for their help in recruiting them, and the whole ALSPAC team, which includes interviewers, computer and laboratory technicians, clerical workers, research scientists, volunteers, managers, receptionists and nurses. The UK Medical Research Council, the Wellcome Trust, and the University of Bristol provide core support for ALSPAC. This work was supported by the World Cancer Research Fund grant number 2009/23. KN designed the study; AS and KN performed the statistical analysis; KN had primary responsibility for final content. All authors contributed to the interpretation of the data and writing the manuscript and approved the final version. The authors declare no conflict of interest.

References

1. Kuh D, Ben-Shlomo Y (2004). *A life course approach to chronic disease epidemiology*, 2nd edn. New York: Oxford University Press.

2. Newby PK, Tucker KL (2004). Empirically derived eating patterns using factor or cluster analysis: a review. *Nutr Rev* **62**, 177-203.

3. Campain AC, Morgan MV, Evans RW, Ugoni A, Adams GG, Conn JA *et al.* (2003). Sugar-starch combinations in food and the relationship to dental caries in low-risk adolescents. *Eur J Oral Sci* **111**, 316-325.

4. Alexy U, Sichert-Hellert W, Kersting M, Schultze-Pawlitschko V (2004). Pattern of long-term fat intake and BMI during childhood and adolescence – results of the DONALD Study. *International Journal of Obesity* **28**, 1203-1209.

5. Pryer JA , Rogers S (2009). Dietary patterns among a national sample of British children aged 1 1/2–4 1/2 years. *Public Health Nutr* **12**, 957-966.

6. Smith ADAC, Emmett PM, Newby PK, Northstone K (2011). A comparison of dietary patterns derived by cluster and principal components analysis in a UK cohort of children. *Eur J Clin Nutr* **65**, 1102-1109.

7. Rasanen M, Lehtinen JC, Niinikoski H, Keskinen S, Ruottinen S, Salminen M *et al.* (2002). Dietary patterns and nutrient intakes of 7-year-old children taking part in an atherosclerosis prevention project in Finland. *J Am Diet Assoc* **102** , 518-524.

8. Song Y, Joung H, Engelhardt K, Yoo SY, Paik HY (2005). Traditional v. modified dietary patterns and their influence on adolescents' nutritional profile. *Br J Nutr* **93**, 943-949.

9. Lee JW, Hwang J, Cho HS (2007). Dietary patterns of children and adolescents analyzed from 2001 Korea National Health and Nutrition Survey. *Nutr Res Pract* **1**, p84-88.

10. Knol LL, Haughton B, Fitzhugh EC (2005). Dietary patterns of young, low-income US children. *J Am Diet Assoc* **105**, 1765-1773.

11. Ritchie LD, Spector P, Stevens MJ, Schmidt MM, Schreiber GB, Striegel-Moore RH *et al.* (2007). Dietary patterns in adolescence are related to adiposity in young adulthood in black and white females. *J Nutr* **137**, 399-406.

12. Margetts BM, Thompson RL, Speller V, McVey D (1998). Factors which influence 'healthy' eating patterns: results from the 1993 Health Education Authority health and lifestyle survey in England. *Public Health Nutrition* **1**, 193-198.

13. Tsai Y, McGlynn KA, Hu Y, Cassidy AB, Arnold J, Engstrom PF *et al.* (2003). Genetic susceptibility and dietary patterns in lung cancer. *Lung Cancer* **41**, 269-281.

14. Millen BE, Quatromoni PA, Nam B, O'Horo CE, Polak JF, Wolf PA *et al.* (2004). Dietary patterns, smoking, and subclinical heart disease in women: opportunities for primary prevention from the Framingham Nutrition Studies. *J Am Diet Assoc* **104**, 208-214.

15. Crozier SR, Robinson SM, Borland SE, Inskip HM, the SWS Study Group (2006). Dietary patterns in the Southampton Women's Survey. *Eur J Clin Nutr* **60**, 1391-1399.

16. Mikkilä V, Räsänen L, Raitakari OT, Pietinen P, Viikari J (2005). Consistent dietary patterns identified from childhood to adulthood: The Cardiovascular Risk in Young Finns Study. *Br J Nutr* **93**, 923-931.

17. Northstone K, Emmett PM (2008). Are dietary patterns stable throughout early and mid-childhood? A birth cohort study. *Br J Nutr* **100**, 1069-1076.

18. Golding J, Pembrey M, Jones R, the ALSPAC Study Team (2001). ALSPAC – The Avon Longitudinal Study of Parent and Children. I. Study methodology. *Paediatr Perinat Epidemiol* **15** 74-87.

19. Jones LR, Steer CD, Rogers IS, Emmett PM (2010). Influences on child fruit and vegetable intake: sociodemographic, parental and child factors in a longitudinal cohort study. *Pub Health Nutr* **13**: 1122-1130.

20. Cribb VL, Jones LR, Rogers IS, Ness AR and Emmett PM (2011). Is maternal education level associated with diet in 10-year-old children? *Public Health Nutr* **14**, 2037-2048.

21. Price GM, Paul AA, Key FB *et al*. (1995) Measurement of diet in a large national survey: comparison of computerised and manual coding of records in household measures. *J Hum Nutr Diet* **8**, 417–428.

22. Northstone K, Emmett P, the ALSPAC Study Team (2005). Multivariate analysis of diet in children at four and seven years of age and associations with socio-demographic characteristics. *Eur J Clin Nutr* **59**, 751-760.

23. Gnanadesikan R, Kettenring JR, Tsao SL (1995). Weighting and selection of variables for cluster analysis. *J Class* **12**, 113-136.

24.Everitt BS, Landau S, Leese M (2001). *Cluster Analysis*, 4th edn. London: Arnold.

25. Kohler U and Brzinsky-Fay C (2005). Stata tip 25: Sequence index plots. *The Stata Journal* **5**, 601-602.

26. Pryer JA, Nichols R, Elliott P, Thakrar B, Brunner E, Marmot M (2001). Dietary patterns among a national random sample of British adults. *J Epidemiol Community Health* **55**, 29-37.

27. Villegas R, Salim A, Collins MM, Flynn A, Perry IJ (2004). Dietary patterns in middle-aged Irish men and women defined by cluster analysis. *Public Health Nutrition* **7**, 1017-1024.

28. North K, Emmett P (2000). Multivariate analysis of diet among three-year old children and associations with socio-demographic characteristics. *Eur J Clin Nutr* **54,** 73-80.

Table 1. Mean (standard deviation) weight (g/day) of foods consumed across clusters for 6837 children aged 7 years.

Food item	**Processed** n=1991	**Healthy** n=1709	**Traditional** n=1558	**Packed lunch** n=1579
Full fat milk	132.3[b] (174.5)	132.9[b] (179.7)	**149.6**[a] (198.3)	80.0[c] (132.4)
Reduced fat milk	97.6[b] (143.1)	**143.6**[a] (178.7)	106.7[b] (148.5)	132.4[a] (167.6)
Cheese	6.7[d] (10.7)	**16.2**[a] (16.2)	8.5[c] (11.8)	14.2[b] (16.5)
Yoghurt, fromage frais	28.1[c] (39.9)	**47.2**[a] (50.2)	34.4[b] (43.8)	37.0[b] (44.9)
Butter, animal fat	2.0[b] (5.5)	**4.5**[a] (8.1)	2.4[b] (5.9)	1.0[c] (4.3)
Margarine	5.8[c] (5.2)	6.7[b] (6.5)	7.2[b] (6.3)	**15.7**[a] (7.1)
Vegetable oil	0.1[b] (0.5)	**0.1**[a] (0.7)	0.1[b] (0.4)	0.1[b] (0.5)
High fibre bread	5.9[c] (15.2)	**25.7**[a] (33.1)	10.1[b] (20.1)	4.2[c] (13.9)
Low fibre bread	43.9[b] (28.1)	39.6[c] (31.8)	45.2[b] (31.3)	**94.2**[a] (33.3)
Special bread	1.1[b] (6.8)	**2.5**[a] (9.8)	1.0[b] (5.6)	1.0[b] (6.2)
Other flour-based products	5.2[b] (12.9)	7.3[b] (16.3)	**9.7**[a] (16.5)	6.6[b] (14.6)
Breakfast cereal	29.6[b] (20.8)	**37.3**[a] (25.8)	31.4[b] (22.3)	25.6[c] (20.7)
Rice	4.1[c] (12.5)	**9.1**[a] (20.6)	5.6[b] (14.8)	4.6[bc](13.7)
Pasta	9.2[c] (19.5)	**27.0**[a] (32.9)	11.9[b] (22.6)	13.1[b] (24.5)
Baked beans, tinned pasta	**42.9**[a] (47.3)	22.6[bc](34.3)	21.2[c] (29.9)	25.8[b] (34.4)
Pizza	**12.7**[a] (25.3)	11.2[a] (23.6)	6.9[b] (18.1)	8.8[b] (21.3)
Eggs	7.3[b] (15.8)	**9.8**[a] (16.8)	6.4[b] (13.7)	7.1[b] (14.7)
Coated and fried chicken	**15.6**[a] (21.4)	6.8[c] (14.5)	7.2[c] (14.7)	9.2[b] (17.0)
Poultry	11.0[c] (18.6)	14.9[b] (21.4)	**25.2**[a] (27.5)	12.8[c] (18.9)
Ham, bacon	5.6[c] (9.6)	7.7[b] (11.1)	7.9[b] (11.7)	**10.6**[a] (14.1)
Red meat	18.6[c] (27.5)	24.4[b] (32.0)	**33.7**[a] (35.9)	22.2[b] (29.1)
Meat pies, pasties	**6.7**[a] (17.0)	3.6[c] (11.0)	6.1[ab](16.4)	5.3[b] (14.3)
Processed meat	**22.4**[a] (24.8)	10.0[c] (15.0)	14.4[b] (19.8)	14.2[b] (19.7)
Coated and fried white fish	**11.1**[a] (17.8)	6.4[b] (13.5)	6.6[b] (13.9)	6.8[b] (14.4)
White fish, shellfish	1.9[b] (10.2)	**3.1**[a] (12.6)	2.4[ab](12.6)	1.7[b] (9.0)
Tuna, oily fish	2.5[b] (9.8)	**6.2**[a] (13.8)	3.5[b] (10.4)	3.4[b] (10.3)
Vegetarian products	1.4[b] (11.2)	**4.3**[a] (23.2)	2.4[b] (19.5)	1.6[b] (10.5)
Chips	**52.9**[a] (32.8)	17.3[d] (21.6)	20.7[c] (22.2)	26.2[b] (25.9)
Roast potatoes	11.5[c] (19.6)	8.1[d] (15.7)	**40.9**[a] (33.0)	14.8[b] (22.2)
Other potatoes	23.2[c] (30.7)	33.1[b] (34.7)	**38.3**[a] (38.3)	25.0[c] (30.8)
Root vegetables	1.1[c] (4.4)	1.8[b] (5.5)	**3.5**[a] (8.8)	1.2[c] (4.4)
Carrots	6.3[d] (9.9)	11.5[b] (14.2)	**24.8**[a] (18.8)	9.0[c] (11.6)
Green leafy vegetables	3.3[d] (6.9)	7.1[b] (11.0)	**17.9**[a] (17.0)	4.6[c] (8.7)
Peas, broad beans, sweetcorn	7.8[c] (12.7)	11.3[b] (14.8)	**15.4**[a] (18.1)	8.6[c] (13.7)
Other cooked vegetable dishes	6.1[b] (13.7)	11.3[a] (20.0)	**12.5**[a] (19.0)	6.5[b] (13.6)
Salad, tomatoes	7.0[c] (15.5)	**24.1**[a] (29.5)	9.8[b] (18.4)	10.7[b] (19.1)
Legumes	0.2[c] (2.0)	**1.1**[a] (6.7)	0.5[b] (4.3)	0.4[b] (4.0)
Soup	4.9[b] (21.6)	**6.8**[a] (24.1)	4.8[c] (19.1)	5.1[bc](20.9)
Nuts, seeds, peanut butter	1.3[b] (4.8)	**2.7**[a] (6.9)	1.3[b] (4.4)	1.4[b] (4.8)
Fresh fruit	47.5[c] (54.1)	**121.7**[a] (84.7)	69.1[b] (65.3)	67.1[b] (63.2)
Other fruit	2.7[c] (11.6)	**6.4**[a] (17.6)	5.0[b] (15.7)	3.4[c] (13.8)
Puddings	10.3[c] (22.2)	12.5[b] (24.2)	**17.7**[a] (27.9)	9.7[c] (21.0)
Dairy puddings	39.8[b] (41.7)	35.2[c] (36.5)	**48.2**[a] (43.8)	36.6[bc](37.9)
Cakes	23.5[b] (25.2)	29.1[a] (29.2)	**29.5**[a] (28.0)	22.9[b] (25.5)
Chocolate	**12.6**[a] (15.9)	8.6[c] (12.4)	10.1[b] (12.8)	12.0[a] (15.4)
Sweets	**8.6**[a] (12.4)	5.5[c] (9.1)	6.9[b] (10.3)	6.4[bc](9.9)
Sugar	**2.9**[a] (4.9)	1.9[c] (3.3)	2.7[ab](4.3)	2.5[b] (4.4)
Sweet spreads	4.2[d] (7.7)	6.3[b] (9.3)	5.1[c] (8.2)	**7.7**[a] (11.6)
Biscuits	26.8[b] (20.8)	20.6[d] (16.8)	22.8[c] (17.7)	**28.9**[a] (20.4)
Crackers, crispbreads	1.7[ab](5.1)	**2.1**[a] (5.2)	1.4[b] (4.1)	2.0[a] (5.6)
Crisps	18.0[b] (13.5)	12.6[d] (10.9)	16.2[c] (12.8)	**23.7**[a] (13.5)

Food item	**Processed** n=1991	**Healthy** n=1709	**Traditional** n=1558	**Packed lunch** n=1579
Low energy density sauce	9.3^{c} (11.3)	10.2^{c} (12.0)	**26.4**^{a} (16.9)	12.2^{b} (12.6)
High energy density sauce	0.6^{c} (2.6)	**1.7**^{a} (4.3)	0.8^{bc}(2.6)	0.9^{b} (2.7)
Salty flavouring	0.2^{c} (0.9)	0.4^{b} (1.1)	0.3^{bc}(1.0)	**0.6**^{a} (1.6)
Water	99.2^{c} (135.1)	**206.3**^{a} (215.4)	156.5^{b} (187.0)	109.4^{c} (160.8)
Fizzy drinks	**54.7**^{a} (112.1)	29.7^{b} (69.3)	32.4^{b} (76.6)	28.5^{b} (72.3)
Diet fizzy drinks	**123.1**^{a} (164.1)	40.6^{d} (81.7)	82.6^{c} (127.5)	100.7^{b} (145.1)
Squash	**79.1**^{a} (142.3)	67.5^{b} (124.7)	75.5^{ab}(134.5)	69.9^{ab}(131.4)
Diet squash	203.1^{b} (222.6)	119.2^{d} (169.5)	177.8^{c} (208.2)	**285.4**^{a} (277.3)
Fruit juice	64.5^{c} (109.4)	**134.6**^{a} (156.4)	76.9^{b} (119.7)	69.9^{bc}(113.5)
Flavoured milk drinks	**18.1**^{a} (49.7)	13.0^{b} (41.2)	13.3^{b} (42.2)	13.3^{b} (44.6)
Tea, coffee	39.8^{a} (90.5)	18.8^{b} (58.0)	37.5^{a} (82.5)	**41.4**^{a} (92.4)

^{abcd} When values in the same row share a superscript letter, there is no difference (p < 0.05) between cluster means, by the Tukey-Cramer method.

The highest and lowest mean in each row are bold and underlined, respectively.

Table 2. Mean (standard deviation) weight (g/day) of foods consumed across clusters for 6972 children aged 10 years.

Food item	**Processed** n=2078	**Healthy** n=1980	**Traditional** n=1489	**Packed lunch** n=1425
Full fat milk	**73.8**[a] (138.9)	48.2[c] (114.2)	57.7[bc] (123.1)	60.5[b] (125.4)
Reduced fat milk	86.3[c] (117.9)	**173.0**[a] (176.9)	125.6[bc] (148.2)	111.7[b] (140.9)
Cheese	7.5[c] (12.1)	**16.7**[a] (18.6)	9.1[bc] (13.4)	16.0[a] (19.9)
Yoghurt, fromage frais	22.1[d] (40.2)	**45.5**[a] (58.0)	28.3[c] (44.2)	34.5[b] (49.1)
Butter, animal fat	2.8[b] (6.7)	**4.0**[a] (8.0)	2.5[b] (6.2)	1.1[c] (4.8)
Margarine	5.4[d] (5.5)	7.0[c] (7.1)	7.9[b] (7.2)	**19.8**[a] (8.7)
Vegetable oil	**0.7**[a] (1.4)	0.5[b] (1.0)	0.5[b] (1.2)	0.5[b] (1.2)
High fibre bread	7.4[bc] (19.6)	**24.5**[a] (35.0)	9.4[b] (22.2)	6.2[c] (18.9)
Low fibre bread	46.6[c] (34.2)	42.7[d] (35.4)	51.2[b] (36.9)	**107.2**[a] (40.8)
Special bread	2.3[b] (10.5)	**4.6**[a] (14.8)	2.8[b] (10.1)	1.9[b] (8.8)
Other flour-based products	6.1[c] (14.5)	7.2[c] (16.1)	**14.3**[a] (21.8)	9.2[b] (19.1)
Breakfast cereal	24.1[c] (20.5)	**31.6**[a] (24.8)	26.3[b] (21.6)	22.1[d] (21.0)
Rice	9.6[b] (26.7)	**15.2**[a] (31.3)	10.3[b] (26.5)	8.9[b] (25.2)
Pasta	17.5[c] (37.0)	**44.5**[a] (54.5)	23.8[b] (41.8)	21.5[b] (38.8)
Baked beans, tinned pasta	**48.4**[a] (65.7)	25.9[c] (43.9)	26.4[c] (44.2)	32.0[b] (50.3)
Pizza	**23.0**[a] (43.3)	18.2[b] (35.9)	12.3[c] (30.9)	16.0[b] (34.1)
Eggs	7.7[c] (17.3)	**10.9**[a] (20.6)	7.8[bc] (16.6)	9.4[ab] (19.3)
Coated and fried chicken	**17.0**[a] (27.5)	5.7[c] (14.8)	7.1[bc] (16.2)	9.1[b] (18.6)
Poultry	18.6[b] (31.2)	21.2[b] (31.7)	**32.1**[a] (35.3)	20.4[b] (31.3)
Ham, bacon	8.4[c] (13.1)	8.7[bc] (13.4)	9.8[b] (13.5)	**15.8**[a] (18.7)
Red meat	25.3[c] (40.6)	34.7[b] (45.4)	**45.9**[a] (48.5)	28.4[c] (40.2)
Meat pies, pasties	**9.2**[a] (24.0)	6.0[b] (18.6)	9.0[a] (21.9)	6.5[b] (18.5)
Processed meat	**24.3**[a] (28.0)	11.9[d] (18.4)	15.1[c] (21.2)	20.2[b] (25.5)
Coated and fried white fish	**9.8**[a] (21.1)	6.2[b] (15.1)	4.5[c] (12.9)	5.6[bc] (15.4)
White fish, shellfish	2.0[ab] (11.8)	**2.7**[a] (11.8)	2.0[ab] (11.7)	1.5[b] (9.1)
Tuna, oily fish	3.0[c] (11.4)	**7.1**[a] (16.7)	4.3[b] (12.4)	4.4[b] (13.8)
Vegetarian products	1.5[b] (13.3)	**4.5**[a] (21.9)	1.9[b] (14.4)	1.2[b] (8.1)
Chips	**69.7**[a] (48.0)	19.7[d] (26.1)	26.0[c] (31.2)	33.9[b] (36.1)
Roast potatoes	12.0[c] (22.4)	9.5[d] (18.9)	**61.1**[a] (43.9)	15.5[b] (25.4)
Other potatoes	23.6[b] (37.9)	37.0[a] (44.2)	**37.9**[a] (47.3)	34.4[a] (45.4)
Root vegetables	1.0[d] (4.5)	2.5[b] (7.8)	**4.1**[a] (9.9)	1.8[c] (6.7)
Carrots	6.1[d] (11.5)	12.4[b] (16.1)	**32.9**[a] (24.4)	9.6[c] (14.3)
Green leafy vegetables	3.4[d] (9.2)	8.1[b] (14.5)	**21.5**[a] (23.0)	5.7[c] (11.8)
Peas, broad beans, sweetcorn	9.6[c] (17.5)	13.4[b] (19.6)	**19.6**[a] (24.0)	10.1[c] (17.3)
Other cooked vegetable dishes	6.4[b] (16.0)	13.7[a] (22.6)	**15.4**[a] (21.9)	7.8[b] (17.5)
Salad, tomatoes	9.6[c] (20.6)	**30.2**[a] (37.7)	12.2[b] (22.3)	14.5[b] (24.8)
Legumes	0.4[b] (3.6)	**1.9**[a] (10.0)	0.7[b] (5.5)	0.3[b] (3.3)
Soup	5.6[b] (24.3)	**11.1**[a] (33.9)	7.1[b] (26.6)	7.1[b] (29.2)
Nuts, seeds, peanut butter	1.0[c] (4.3)	**2.3**[a] (6.4)	1.2[bc] (4.5)	1.6[b] (6.0)
Fresh fruit	35.9[c] (49.8)	**102.6**[a] (84.9)	62.4[b] (66.3)	60.1[b] (68.1)
Other fruit	3.2[c] (13.3)	**6.1**[a] (16.1)	4.9[ab] (15.5)	3.7[bc] (14.3)
Puddings	8.9[c] (22.6)	11.6[b] (25.0)	**19.9**[a] (33.6)	7.6[c] (20.7)
Dairy puddings	33.8[b] (41.4)	32.1[b] (36.9)	**49.2**[a] (48.2)	27.7[c] (35.3)
Cakes	21.6[c] (27.2)	**30.4**[a] (32.2)	25.6[b] (29.4)	23.0[bc] (27.6)
Chocolate	**15.0**[a] (19.6)	11.1[c] (15.0)	13.4[b] (17.4)	12.4[bc] (16.1)
Sweets	**9.5**[a] (15.5)	5.8[c] (10.8)	7.9[b] (12.7)	8.2[b] (13.6)
Sugar	3.6[a] (5.2)	2.8[b] (4.4)	**3.7**[a] (5.5)	3.4[a] (5.3)
Sweet spreads	4.2[c] (8.2)	5.8[b] (9.2)	5.4[b] (8.8)	**7.3**[a] (11.5)
Biscuits	24.4[b] (23.2)	20.7[c] (18.2)	23.5[b] (20.6)	**28.8**[a] (22.8)
Crackers, crispbreads	1.2[b] (4.4)	**2.5**[a] (6.4)	1.4[b] (4.5)	2.1[a] (6.1)
Crisps	20.9[b] (16.6)	13.4[d] (12.2)	18.1[c] (14.1)	**23.8**[a] (15.3)

Food item	**Processed** n=2078	**Healthy** n=1980	**Traditional** n=1489	**Packed lunch** n=1425
Low energy density sauce	11.4^{c} (14.6)	14.9^{b} (17.1)	**35.7**^{a} (21.7)	13.8^{b} (15.2)
High energy density sauce	1.2^{c} (3.8)	**2.5**^{a} (5.3)	1.4^{bc} (3.8)	1.6^{b} (4.0)
Salty flavouring	0.2^{c} (0.8)	0.3^{b} (1.0)	0.3^{bc} (1.0)	**0.8**^{a} (1.9)
Water	118.5^{c} (183.2)	**245.8**^{a} (276.1)	177.6^{b} (238.8)	146.6^{d} (215.8)
Fizzy drinks	**113.6**^{a} (175.5)	46.7^{c} (94.4)	61.1^{b} (118.1)	68.9^{b} (133.8)
Diet fizzy drinks	**88.3**^{a} (159.2)	39.5^{c} (101.0)	71.6^{b} (139.4)	82.4^{ab} (154.1)
Squash	58.3^{a} (106.7)	**61.0**^{a} (113.3)	58.0^{a} (112.4)	58.5^{a} (110.9)
Diet squash	137.7^{b} (167.1)	87.9^{b} (137.6)	133.3^{b} (166.5)	**185.7**^{a} (199.8)
Fruit juice	82.9^{c} (125.5)	**176.0**^{a} (179.4)	108.4^{b} (142.8)	95.5^{bc} (135.3)
Flavoured milk drinks	23.9^{a} (68.4)	21.3^{a} (58.7)	23.4^{a} (67.0)	**25.1**^{a} (70.0)
Tea, coffee	44.1^{b} (98.2)	37.0^{b} (90.6)	56.5^{a} (121.0)	**61.6**^{a} (126.8)

^{abcd} When values in the same row share a superscript letter, there is no difference ($p < 0.05$) between cluster means, by the Tukey-Cramer method.

The highest and lowest mean in each row are bold and underlined, respectively.

Table 3. Mean (standard deviation) weight (g/day) of foods consumed across clusters for 5661 children aged 13 years.

Food item	**Processed** n=1813	**Healthy** n=1728	**Traditional** n=1108	**Packed lunch** n=1012
Full fat milk	**47.6**^{a} (133.8)	29.5^{c} (101.9)	32.7^{bc} (105.6)	41.7^{ab} (118.1)
Reduced fat milk	109.1^{c} (141.7)	**182.4**^{a} (190.8)	160.6^{b} (184.5)	142.9^{b} (172.8)
Cheese	10.0^{b} (16.1)	**20.3**^{a} (21.5)	11.6^{b} (16.2)	19.9^{a} (23.9)
Yoghurt, fromage frais	18.1^{c} (41.4)	**37.1**^{a} (60.1)	28.9^{b} (52.4)	20.0^{c} (41.7)
Butter, animal fat	3.3^{a} (7.5)	**3.8**^{a} (8.3)	3.5^{a} (7.4)	2.3^{b} (8.2)
Margarine	4.8^{b} (5.9)	6.5^{b} (7.7)	6.6^{b} (7.7)	**19.5**^{a} (10.9)
Vegetable oil	0.0^{b} (0.3)	**0.2**^{a} (0.8)	0.1^{b} (0.5)	0.1^{b} (0.6)
High fibre bread	12.5^{c} (25.3)	**44.2**^{a} (43.9)	22.2^{b} (32.9)	9.0^{d} (24.1)
Low fibre bread	46.7^{b} (37.1)	30.0^{c} (33.8)	45.0^{b} (41.5)	**124.3**^{a} (50.5)
Special bread	4.4^{b} (14.2)	**8.7**^{a} (20.7)	4.4^{b} (14.4)	4.4^{b} (16.2)
Other flour-based products	6.9^{b} (19.2)	6.5^{b} (17.8)	**14.7**^{a} (23.3)	7.7^{b} (19.7)
Breakfast cereal	22.8^{c} (25.5)	**36.6**^{a} (33.6)	29.4^{b} (28.8)	25.6^{c} (28.0)
Rice	15.1^{b} (38.2)	**22.5**^{a} (42.1)	14.2^{b} (33.5)	17.0^{b} (40.7)
Pasta	20.3^{c} (40.9)	**65.8**^{a} (73.5)	25.4^{bc} (44.6)	28.7^{b} (52.7)
Baked beans, tinned pasta	**41.1**^{a} (66.7)	25.0^{c} (48.7)	23.8^{c} (46.7)	32.7^{b} (61.7)
Pizza	**32.0**^{a} (57.4)	18.6^{bc} (41.9)	16.7^{c} (39.3)	23.4^{b} (52.9)
Eggs	8.0^{b} (19.8)	**11.2**^{a} (23.5)	8.3^{b} (20.1)	10.3^{a} (22.6)
Coated and fried chicken	**13.4**^{a} (30.9)	3.8^{c} (14.5)	5.0^{bc} (16.8)	6.8^{b} (19.1)
Poultry	27.5^{b} (42.2)	29.4^{b} (40.5)	**44.3**^{a} (47.3)	30.9^{b} (44.0)
Ham, bacon	10.1^{b} (15.4)	11.2^{b} (16.7)	11.7^{b} (16.8)	**20.5**^{a} (24.0)
Red meat	37.0^{b} (57.8)	38.3^{b} (56.5)	**50.3**^{a} (61.4)	41.3^{b} (57.3)
Meat pies, pasties	**13.7**^{a} (32.1)	6.8^{c} (20.2)	11.1^{ab} (26.1)	9.4^{bc} (25.0)
Processed meat	**23.4**^{a} (34.8)	10.4^{c} (20.2)	13.6^{b} (23.3)	20.6^{a} (30.5)
Coated and fried white fish	**8.4**^{a} (22.9)	4.3^{b} (14.4)	4.2^{b} (14.1)	5.1^{b} (16.0)
White fish, shellfish	2.7^{b} (14.3)	**4.2**^{a} (16.6)	2.0^{b} (10.6)	1.8^{b} (9.9)
Tuna, oily fish	5.9^{b} (19.0)	**10.1**^{a} (22.7)	5.8^{b} (16.1)	7.5^{b} (21.1)
Vegetarian products	2.3^{b} (18.2)	**6.1**^{a} (24.1)	3.3^{b} (22.0)	2.2^{b} (15.5)
Chips	**66.7**^{a} (61.8)	16.3^{d} (28.9)	23.7^{c} (34.3)	33.6^{b} (42.6)
Roast potatoes	7.9^{c} (20.0)	7.0^{c} (18.3)	**70.5**^{a} (51.8)	14.3^{b} (27.9)
Other potatoes	32.0^{b} (51.5)	41.7^{a} (52.2)	**41.8**^{a} (55.2)	37.8^{a} (51.9)
Root vegetables	1.2^{c} (4.9)	3.1^{b} (8.9)	**7.2**^{a} (17.2)	2.0^{c} (7.7)
Carrots	6.4^{c} (13.2)	11.6^{b} (17.9)	**38.4**^{a} (30.3)	9.6^{b} (16.9)
Green leafy vegetables	3.3^{c} (9.3)	8.2^{b} (15.6)	**24.6**^{a} (26.1)	6.6^{b} (14.2)
Peas, broad beans, sweetcorn	9.6^{c} (18.1)	12.2^{b} (20.8)	**20.6**^{a} (26.5)	10.4^{c} (20.3)
Other cooked vegetable dishes	11.4^{b} (26.4)	**22.8**^{a} (35.6)	21.8^{a} (33.8)	11.2^{b} (24.8)
Salad, tomatoes	14.4^{c} (26.1)	**42.5**^{a} (47.0)	15.2^{c} (25.8)	20.3^{b} (33.6)
Legumes	0.6^{b} (6.2)	**3.3**^{a} (14.0)	0.5^{b} (5.0)	0.7^{b} (6.3)
Soup	8.3^{b} (32.3)	**12.0**^{a} (37.2)	9.0^{ab} (32.4)	9.6^{ab} (38.6)
Nuts, seeds, peanut butter	0.7^{c} (3.7)	**2.6**^{a} (7.9)	1.6^{b} (6.3)	1.4^{b} (6.3)
Fresh fruit	39.2^{c} (60.5)	**122.2**^{a} (108.5)	68.7^{b} (82.0)	64.5^{b} (79.7)
Other fruit	4.5^{b} (23.2)	**10.3**^{a} (33.9)	6.5^{b} (29.9)	4.0^{b} (21.7)
Puddings	7.1^{c} (22.1)	9.3^{b} (23.6)	**16.0**^{a} (32.5)	7.7^{bc} (22.5)
Dairy puddings	20.7^{c} (36.5)	24.2^{b} (37.4)	**31.9**^{a} (46.6)	24.8^{b} (40.3)
Cakes	19.7^{c} (30.0)	25.7^{b} (34.0)	**29.9**^{a} (37.0)	22.6^{bc} (32.2)
Chocolate	13.4^{a} (21.7)	9.2^{b} (15.8)	**13.6**^{a} (19.8)	11.8^{a} (19.2)
Sweets	**6.5**^{a} (15.3)	4.1^{c} (10.8)	5.1^{bc} (13.1)	5.7^{ab} (15.0)
Sugar	3.1^{a} (5.8)	2.1^{b} (4.5)	3.1^{a} (5.7)	**3.4**^{a} (6.4)
Sweet spreads	2.4^{b} (6.5)	4.3^{b} (8.6)	4.1^{b} (8.7)	**6.0**^{a} (12.5)
Biscuits	19.5^{c} (24.1)	21.3^{bc} (22.2)	23.6^{b} (25.1)	**26.6**^{a} (26.0)
Crackers, crispbreads	1.3^{b} (5.0)	**2.4**^{a} (6.9)	1.6^{b} (5.1)	2.2^{a} (6.5)
Crisps	16.4^{b} (16.5)	11.3^{d} (12.9)	13.7^{c} (13.8)	**19.6**^{a} (16.9)

Food item	**Processed** n=1813	**Healthy** n=1728	**Traditional** n=1108	**Packed lunch** n=1012
Low energy density sauce	13.8^{d} (19.3)	22.3^{b} (27.0)	**43.4**^{a} (30.3)	17.7^{c} (21.5)
High energy density sauce	1.7^{c} (4.7)	**3.6**^{a} (6.9)	1.9^{bc} (4.9)	2.5^{b} (6.6)
Salty flavouring	0.2^{b} (0.7)	0.4^{b} (1.2)	0.3^{b} (1.2)	**0.6**^{a} (1.9)
Water	442.3^{d} (379.8)	**711.9**^{a} (498.2)	552.9^{c} (438.5)	645.6^{b} (484.8)
Fizzy drinks	**144.2**^{a} (219.8)	49.8^{c} (110.1)	87.9^{b} (169.0)	96.4^{b} (175.0)
Diet fizzy drinks	**103.0**^{a} (199.7)	36.1^{c} (101.9)	60.2^{b} (139.4)	72.1^{b} (150.5)
Squash	**70.0**^{a} (150.3)	62.0^{a} (134.6)	58.0^{a} (134.1)	66.1^{a} (160.9)
Diet squash	126.2^{c} (204.8)	132.1^{bc} (238.6)	154.4^{b} (254.2)	**233.0**^{a} (319.6)
Fruit juice	112.0^{d} (163.3)	**189.2**^{a} (204.7)	162.0^{b} (192.4)	131.9^{c} (185.3)
Flavoured milk drinks	**29.7**^{a} (85.3)	16.8^{b} (55.1)	23.2^{ab} (65.7)	22.4^{b} (67.9)
Tea, coffee	68.7^{b} (138.2)	62.5^{b} (139.3)	**88.0**^{a} (168.1)	87.3^{a} (164.0)

^{abcd} When values in the same row share a superscript letter, there is no difference ($p < 0.05$) between cluster means, by the Tukey-Cramer method.

The highest and lowest mean in each row are bold and underlined, respectively.

Table 4. Cross-tabulations between cluster membership at different ages.

	Cluster at 7				
	Processed	Healthy	Traditional	Packed lunch	Total
Cluster at 10					
Processed	649 (43%)	215 (16%)	307 (25%)	321 (27%)	1492 (28%)
Healthy	276 (18%)	735 (54%)	318 (26%)	233 (19%)	1562 (30%)
Traditional	302 (20%)	217 (16%)	393 (32%)	238 (20%)	1150 (22%)
Packed lunch	278 (18%)	191 (14%)	203 (17%)	411 (34%)	1083 (21%)
Total	1505	1358	1221	1203	5287
	Cluster at 10				
	Processed	Healthy	Traditional	Packed lunch	Total
Cluster at 13					
Processed	623 (46%)	309 (21%)	326 (30%)	288 (29%)	1546 (31%)
Healthy	277 (21%)	751 (50%)	261 (24%)	236 (24%)	1525 (31%)
Traditional	242 (18%)	272 (18%)	283 (26%)	174 (17%)	971 (20%)
Packed lunch	199 (15%)	167 (11%)	203 (19%)	306 (30%)	875 (18%)
Total	1341	1499	1073	1004	4917
	Cluster at 7				
	Processed	Healthy	Traditional	Packed lunch	Total
Cluster at 13					
Processed	532 (43%)	236 (20%)	275 (27%)	318 (33%)	1361 (31%)
Healthy	252 (20%)	592 (50%)	296 (29%)	247 (26%)	1387 (32%)
Traditional	245 (20%)	207 (17%)	280 (27%)	153 (16%)	885 (20%)
Packed lunch	206 (17%)	152 (13%)	173 (17%)	241 (25%)	772 (18%)
Total	1235	1187	1024	959	4405

Table 5: Adjusted[a] associations between maternal characteristics and cluster membership over time (each group compared to all other combinations of cluster membership; n=1975)

	Processed cluster at all 3 timepoints (n=240)	**Processed cluster at any 2 timepoints (n=692)**	**Healthy cluster at timepoints (n=353**
Gender			
Boy (n=1874)	1.00	1.00	1.00

	Processed cluster at all 3 timepoints (n=240)	Processed cluster at any 2 timepoints (n=692)	Healthy cluster at timepoints (n=353
Girl (n=2100)	1.25 (0.94, 1.67)	1.07 (0.89, 1.28)	1.51 (1.25, 1.83)
Ethnicity			
White (n=3575)	1.00	1.00	1.00
Non-white (n=109)	2.28 (1.11, 4.68)	1.24 (0.70, 2.19)	1.38 (0.81, 2.36)
Maternal age			
≤ 24 (n=292)	1.00	1.00	1.00
25 – 30 (n=1157)	0.99 (0.64, 1.53)	1.00 (0.75, 1.35)	1.29 (0.88, 1.91)
30+ (n=1240)	0.73 (0.46, 1.15)	0.91 (0.67, 1.23)	1.94 (1.32, 2.85)
Maternal education[b]			
< O level (n=616)	1.00	1.00	1.00
O level (n=1324)	0.94 (0.65, 1.35)	0.80 (0.62, 1.02)	1.83 (1.25, 2.69)
>O Level (n=1786)	0.51 (0.33, 0.77)	0.67 (0.52, 0.86)	4.39 (3.05, 6.35)
Maternal smoking			
Never (n=2238)	1.00	1.00	1.00
Ever (n=1501)	0.96 (0.71, 1.30)	1.00 (0.83, 1.21)	1.05 (0.86, 1.27)
Housing tenure			
Owned/Mortgaged (n=3240)	1.00	1.00	1.00
Council/Housing assoc (n=215)	1.06 (0.60, 1.88)	1.32 (0.92, 1.91)	0.69 (0.37, 1.31)
Rented/Other (n=258)	0.89 (0.48, 1.64)	1.12 (0.77, 1.64)	1.43 (0.97, 2.09)

[a] each factor adjusted for all other factors in the table

[b] O levels are examinations achieved at the age of 16

Figure 1: Sequence Index Plot illustrating changes in cluster membership over time