

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

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22 **Running title:** Longitudinal dietary patterns in children

23 **Abstract**

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

42

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

45

## 46 **Introduction**

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

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

63 Despite the diverse cultures represented in the published literature, similar patterns of dietary  
64 intake have been identified across studies. Two dichotomous patterns have often been  
65 described in adult studies <sup>(12-15)</sup>: These have been labeled either as ‘prudent’ or ‘healthy’,  
66 being related to high intakes of fruit, vegetables, cereals and low-fat dairy products or ‘less  
67 healthy’, being related to high intakes of meat, processed meats and added sugar. It is quite  
68 likely that an individual’s adult diet is heavily influenced by their childhood diet and it would

69 therefore be important to examine any change in dietary patterns over time prior to  
70 adulthood. Such changes, during childhood and from childhood into early adulthood, have  
71 been investigated with principal components analysis <sup>(16, 17)</sup> but we are not aware of any  
72 studies that have examined them using dietary patterns obtained from cluster analysis.

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

80

## 81 **Subjects and Methods**

82 The Avon Longitudinal Study of Parents and Children (ALSPAC) is a population-based birth  
83 cohort study investigating environmental, genetic and other influences on development and  
84 health <sup>(18)</sup>. Pregnant women living in the Avon health authority area (South West England)  
85 with expected dates of delivery between April 1991 and December 1992, inclusive, were  
86 eligible to participate. The current study includes children in the core ALSPAC sample,  
87 consisting of 14541 pregnancies together with children from an additional 542 eligible  
88 pregnancies that were invited to participate at a later date. There were 14535 children alive at  
89 1 year of age comprising the baseline sample. Further details can be obtained from the  
90 ALSPAC website (<http://www.bristol.ac.uk/alspac>). Ethical approval was obtained from the  
91 ALSPAC Law and Ethics Committee and the Local Research Ethics Committees.

92 Children were invited to attend hands-on research clinics when they were 7, 10 and 13 years  
93 of age. The mean age at attendance was 7 years 7 months (s.d. 4 months), 10 years 8 months  
94 (s.d. 3 months), and 13 years 10 months (s.d. 2 months) respectively. Prior to each clinic the  
95 subjects were sent a 3-day diet diary for care-giver completion at 7 years and child  
96 completion at 10 and 13 years, recording all food and drink consumed over two weekdays  
97 and one weekend day. During the 10 and 13 years clinics, a nutritionist conducted an  
98 interview to clarify portion sizes and any omitted foods and drinks. 24 hour recalls were  
99 conducted if the child did not bring a completed diary to the clinic with them (<10% at each  
100 time point). Further details on the recording and coding of the dietary data can be found  
101 elsewhere <sup>(19, 20)</sup>; briefly the completed diaries were entered into the DIDO (Diet In Data Out)  
102 computer program <sup>(21)</sup>, which generated a weight for every food consumed by each child  
103 based on the description given in the diary. For the purposes of this study the average weight

104 of each food consumed over the three days was used. Foods were allocated to 62 groups  
105 which were based primarily on the food groups used in FFQs administered to the same  
106 subjects <sup>(6, 17, 22)</sup>; additional groups were included to allow for foods not covered by the FFQ  
107 (such as salty flavourings and sauces). The average weights (g/day) consumed in each group  
108 were used as input variables for cluster analysis.

## 109 **Statistical methods**

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

120 The cluster analysis used the *k*-means algorithm, the most common method used in dietary  
121 studies <sup>(2)</sup>. This method minimizes the sum of squares of differences between each child and  
122 the mean of his/her cluster. The standard *k*-means algorithm can give incorrect cluster  
123 solutions <sup>(24)</sup> and it was therefore run 100 times, with different starting positions, to find the  
124 solution with smallest sum of squares differences. To examine the stability of the final  
125 solution, the data were randomly split and analyses performed on separate halves. The

126 number of children allocated to a different cluster gave a measure of stability of the solution.  
127 This procedure was repeated five times.

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

## 149 **Results**

150 At age 7, 8299 children attended the clinic with 7285 (88%) providing diet diaries. Of these,  
151 6837 (94%) children were available for analysis after outlier removal. At age 10, 7563  
152 children attended, 7473 (99%) provided diaries and 6972 (93%) were available after outlier  
153 removal. At age 13, 6147 children attended with 6105 (99%) providing diaries and 5661  
154 (93%) remained after outlier removal. Dietary data was more likely to be available for girls,  
155 white children, children with older, higher educated and non-smoking mothers, and those  
156 living in homes that were owned or mortgaged. These inequalities were similar across the  
157 three ages (data not shown).

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

167 The largest cluster at each age, which we chose to label Processed, had higher mean  
168 consumption of processed meat, pies and pasties, coated and fried chicken and white fish,  
169 pizza, chips, baked beans and tinned pasta, chocolate, sweets, sugar, and diet and regular  
170 fizzy drinks compared to the other clusters. The second-largest cluster at each age, which we  
171 chose to label Healthy, had higher mean consumption of non-white bread, reduced fat milk,



172 cheese, yoghurt and fromage frais, butter, breakfast cereal, rice, pasta, eggs, fish, vegetable  
173 and vegetarian dishes, soup, salad, legumes, fruit, crackers and crispbreads, high energy-  
174 density sauces (e.g. mayonnaise), fruit juice, and water. The third cluster had higher mean  
175 consumption of red meat, poultry, potatoes, vegetables, flour-based products (e.g. Yorkshire  
176 pudding), low energy-density sauces (e.g. gravy), puddings, tea and coffee. This cluster was  
177 given the label “Traditional”, in line with a traditional British diet. The final cluster had  
178 higher mean consumption of white bread, margarine, ham and bacon, sweet spreads (e.g.  
179 honey), salty flavourings (e.g. yeast extract), crisps, biscuits, diet squash, tea and coffee. This  
180 cluster was labeled “Packed Lunch”, because in school aged children these foods are often  
181 eaten in packed lunches.

182 Table 4 shows the cluster membership at 10 and 13 years of age tabulated against cluster  
183 membership at 7 years. It also shows the proportion of children who remained in each cluster  
184 between ages. The highest proportions staying in the same cluster were seen for the Healthy  
185 cluster: 54% of children in this cluster at age 7 remained in it at age 10 and 50% were still in  
186 it at age 13. Of those in the Healthy cluster at age 10, 50% remained there at age 13. The  
187 Processed cluster at age 7 also showed reasonable stability over time: 43% and 46% of  
188 children in this cluster at 7 were still in it at 10 and 13 respectively, while 43% in it at 10  
189 remained there at 13. The Traditional and Packed Lunch clusters were less stable with 25% to  
190 34% remaining in those clusters over time. The proportion of children who stayed in the  
191 same cluster at all three ages was 20%: for individual clusters the greatest stability was seen  
192 for the Healthy cluster 33% with the processed cluster second at 22%. Figure 1 illustrates the  
193 tracking of cluster membership over time and shows that the most consistent cluster  
194 membership over time was for the Healthy cluster, followed by the Processed cluster.

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

205

## 206 **Discussion**

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

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

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

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

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

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

285

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

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

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

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371 <sup>abcd</sup> When values in the same row share a superscript letter, there is no difference ( $p < 0.05$ )  
372 between cluster means, by the Tukey-Cramer method.

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

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

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

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

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380 <sup>abcd</sup> When values in the same row share a superscript letter, there is no difference ( $p < 0.05$ )  
381 between cluster means, by the Tukey-Cramer method.

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

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

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

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

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389 <sup>abcd</sup> When values in the same row share a superscript letter, there is no difference ( $p < 0.05$ )  
390 between cluster means, by the Tukey-Cramer method.

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

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

	Cluster at 7				Total
	Processed	Healthy	Traditional	Packed lunch	
<b>Cluster at 10</b>					
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				Total
	Processed	Healthy	Traditional	Packed lunch	
<b>Cluster at 13</b>					
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				Total
	Processed	Healthy	Traditional	Packed lunch	
<b>Cluster at 13</b>					
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

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397 **Table 5: Adjusted<sup>a</sup> associations between maternal characteristics and cluster**  
 398 **membership over time (each group compared to all other combinations of cluster**  
 399 **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)
<b>Gender</b>			
Boy (n=1874)	1.00	1.00	1.00

	<b>Processed cluster at all 3 timepoints (n=240)</b>	<b>Processed cluster at any 2 timepoints (n=692)</b>	<b>Healthy cluster at timepoints (n=353)</b>
Girl (n=2100)	1.25 (0.94, 1.67)	1.07 (0.89, 1.28)	1.51 (1.25, 1.83)
<b>Ethnicity</b>			
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)
<b>Maternal age</b>			
≤ 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)
<b>Maternal education<sup>b</sup></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)
<b>Maternal smoking</b>			
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)
<b>Housing tenure</b>			
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)

400 <sup>a</sup> each factor adjusted for all other factors in the table

401 <sup>b</sup> O levels are examinations achieved at the age of 16

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