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1 **A cross-sectional assessment of food and nutrient based**
2 **standards applied to British school children's packed**
3 **lunches**

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30

31 **Conflict of interest**

32 CELE and JEC have no further financial support. CELE and JEC have no other relationships with
33 companies that might have an interest in the submitted work. CELE and JEC have no non-
34 financial interests that may be relevant to the submitted work.

35

36 **Statement on ethics**

37 This study was approved by the University of Leeds Ethics Committee. The trial registry code is
38 ISRCTN77710993.

39

40 **Author contributions**

41 CELE designed the research protocol and statistical analysis plan, CELE wrote the first
42 manuscript, carried out the analysis and contributed to all versions of the manuscript. JEC secured
43 the funding for the original project and contributed to all versions of the manuscript.

44

45 **ABSTRACT**

46 Purpose: In England, standards for school meals included both foods and nutrients until 2015. School
47 policies for packed lunches are generally food based; research is needed to determine whether these are
48 adequate or whether a small number of nutrients would potentially improve their quality.

49 Methods: dietary data from 1294 British children in 89 schools, aged 8-9 years taking a packed lunch were
50 included. A diet quality score (DQS) for lunches was calculated using the number of standards met out of
51 21 (8 foods and 13 nutrients). Multilevel regression analysis determined the foods and nutrients
52 contributing to variation in the DQS.

53 Results: The optimal model included all 8 foods and 7/13 nutrients; explaining 72% of the variance in DQS.
54 Folate, iron and vitamin C, together with the 8 food groups explained 70% of DQS variation.

55 Conclusions: Ideally, policies for school packed lunches should include food based standards plus
56 recommendations based on a small number of nutrients.

57 INTRODUCTION

58 Ensuring that children eat a high quality diet is a key component of public health programmes aiming to
59 reduce childhood obesity⁽¹⁾. National age specific recommended levels of foods and nutrients are set by
60 many countries in Europe,^(2, 3) the USA⁽⁴⁾ and Australia⁽⁵⁾. A nutritious diet contains foods such as fruits
61 and vegetables, protein and dairy foods rich in micronutrients; and is low in fats, particularly saturated
62 fat, added sugars and salt.

63 In England, nutrient and food based standards exist for school meals ^(6; 7). The food based standards
64 restrict use of fatty and fried foods, snacks, foods high in sugar including sweetened drinks/snacks and
65 encourage increased consumption of fruits and vegetables. In addition to food based standards, there are
66 a total of 14 nutrient standards for school meals (13 nutrients plus energy) four have a maximum level
67 (total fat, saturated fat, added sugars and sodium) and nine have a minimum level (protein, carbohydrate,
68 fibre, vitamin A, vitamin C, folate, calcium, iron and zinc). The standard for energy has a tolerance of 5%
69 below and above the standard⁽⁸⁾. A move towards food rather than nutrient based standards resulted
70 from The School food Plan in January 2015, however its impact on quality of school food has not yet been
71 fully evaluated⁽⁹⁾. Packed lunches are not required to meet these same standards but many schools follow
72 government recommendations and have a food based packed lunch policy in place to improve the quality
73 of food brought from home at lunchtime⁽¹⁰⁾.

74 Simple but effective methods to assess the quality of children's meals, whether provided at school or
75 brought from home are required. Tools to assess overall dietary quality have been designed for both
76 adults and children but not for specific meal times⁽¹¹⁾. Measures of dietary quality in children include the
77 Healthy Eating Index for children and the revised diet quality index, both of which are from the USA and
78 are based on daily food intakes⁽¹²⁾.

79 The European Commission has recently published a report on the 34 school food policies in 30 countries
80 in Europe ⁽¹³⁾; Out of the total, 31 policies included food based standards and 23, nutrient based
81 standards⁽¹³⁾. Policies for packed lunches exist in some schools and consist of food based
82 recommendations by individual schools rather than legally binding regional standards. However, it is not
83 known whether these recommendations are sufficient to ensure a high quality lunch brought from home
84 as research has been carried out in school meals ⁽¹⁴⁾ but not in packed lunches.

85 The aims of this research are two-fold. Firstly, to analyse children's lunches brought from home to identify
86 the most important nutrients that predict a good quality packed lunch compared with recommended and
87 restricted foods and secondly to suggest a method to measure lunch quality that can be used to assess
88 lunches brought from home. These results will enable schools to make simple and informed
89 recommendations as part of a packed lunch policy that build on existing food based guidelines.

90 **METHODS**

91 ***Study design***

92 Data was collected in 2006 from 1294 children attending 29 primary schools randomly selected from all
93 state schools across the four regions in the UK; England, Wales, Scotland and Northern Ireland. One class
94 of children in year 4 (aged 8 to 9 years) was randomly sampled from each primary school. The data
95 analysed here are part of a cluster randomised controlled trial to improve packed lunches and further
96 details on sampling procedures are provided in published papers^(15; 16).

97 Dietary data was collected using a weighed dietary assessment tool designed to measure the food in
98 children's packed lunches. Individual foods were weighed whenever possible and entered under the
99 following categories: drinks, sandwiches, savoury snacks, vegetables, fruit and sweet snacks. Sandwiches
100 and mixed salads were weighed in their entirety and different parts of the sandwich were estimated
101 based on reported average portion sizes⁽¹⁷⁾. Thirteen nutrients included in the nutrient standards for
102 school meals in England (excluding energy as it has both a maximum and minimum standard) were
103 calculated for each child's lunch using Dante; a programme designed in-house based on the 6th edition of
104 the composition of foods⁽¹⁸⁾. These were total and saturated fat (g), carbohydrate (g), non-milk extrinsic
105 sugars (g), protein (g), fibre (NSP) (g), calcium (mg), iron (mg), zinc (mg), folate (mg), vitamin A (mcg),
106 vitamin C (mg) and sodium (mg). The presence or absence of 8 specific food groups included in the food
107 based standards was also calculated by an experienced nutritionist, based on information provided by
108 trained administrators. These include 5 healthy foods namely; a protein rich food (cheese, meat, fish or
109 legumes), low fat carbohydrate food (bread, rice or pasta), dairy rich food (cheese, yogurt), fruit and
110 vegetable. Three foods restricted in the school meal standards included sweetened drinks, confectionery
111 (cakes and biscuits containing chocolate, chocolate and sugar confectionery and cereal bars) and savoury
112 snacks.

113 Nutrients and food based standards for the lunch meal were combined to produce a dietary quality score
114 (DQS) for each lunch with a minimum of zero and a maximum score of 21. This score was based on how
115 many nutrient standards each lunch met (out of 13) together with how many healthy foods were included
116 in the lunch (out of 5) and how many restricted foods were not included in the lunch (out of 3). A top
117 score of 21 was obtained if all the nutrient standards were met, all 5 healthy foods were included and
118 none of the restricted foods were included in the child's lunch.

119 ***Statistical analysis***

120 All statistical analyses were carried out using STATA 12.0.⁽¹⁹⁾ The distribution for lunch quality score was
121 checked to ensure a normal distribution before analysis. Multilevel regression modelling was used to take
122 into account the clustering effect of children within schools. Variables showing an extremely skewed

123 distribution were considered for transformation to the natural logarithm before carrying out statistical
124 tests. Model fit was checked by inspecting histograms of the residuals.

125 Multilevel regression analysis was performed in three steps to identify important nutrient variables
126 explaining variability in the DQS in conjunction with foods. Firstly, a Forwards stepwise regression method
127 was used beginning with all 8 foods (forced into the model) and adding nutrients into the model one at a
128 time until no new nutrients significantly explained variation in lunch quality score. Secondly, individual
129 models for each significant nutrient in conjunction with foods were produced in order to identify the most
130 important single nutrients contributing to variation in lunch quality. Thirdly, the nutrients most strongly
131 associated with lunch quality score were included in the model with all 8 foods. The percent variance
132 explained by each model was reported as well as the intraclass correlation (ICC), percent of variation at
133 the school level.

134 Lunches were split into quintiles of nutrients strongly associated with DQS to graphically display change in
135 lunch quality score with increased nutrient provision. Changes in score by quintiles of food groups were
136 also displayed.

137 **RESULTS**

138 Data on lunch time intake was collected from 1294 children. Of these, 631 (49%) were male and 661
139 (51%) were female and 2 children had no information on gender collected. No lunches were excluded
140 from the analysis. Mean DQS for all lunches was 10.0 (95% CI 9.7 to 10.2) and had an approximately
141 normal distribution. No lunches met all 21 standards. The mean number of nutrient standards met out of
142 a total of 13 for each lunch excluding energy was 6.0 (95% CI 5.9 to 6.2) with a median of 6. One lunch
143 met all 13 standards and the lowest number of standards met was 1. The mean number of food based
144 standards met out of a total of 8 (5 healthy and 3 restricted) was 4.0 (95% CI 3.8 to 4.1) and a median of 4.
145 Thirteen lunches (1%) met all the food based standards while seven lunches did not meet any of the food
146 based standards. More details on individual foods and nutrients are published elsewhere⁽¹⁵⁾. All
147 distributions of lunch quality score, food and nutrient based standards were approximately normal and
148 therefore none were transformed.

149 Multiple regression was carried out using DQS as the outcome variable. The full regression model
150 revealed that the 13 nutrients and 8 foods explained 74% of the variation in DQS (see table 1). Models
151 with only nutrients or only food groups explained lower levels of variation in DQS (see table 1). Forward
152 stepwise regression with all food groups in the model excluded 6 nutrients namely: total fat,
153 carbohydrate, added sugars, fibre, zinc and vitamin A as these nutrients explained very little of the
154 variation in DQS. Seven nutrients remained in the model; these were saturated fat, calcium, iron, vitamin

155 C, protein, sodium and folate. The regression model with all 8 food groups and the 7 significant nutrients
156 explained 72% of the variation in quality score. The models with each individual nutrient in turn in
157 conjunction with the 8 foods revealed that iron, folate, vitamin C, protein and fibre (NSP) were important
158 individual nutrients in terms of predicting lunch quality in addition to foods.

159 The three nutrients consistently important in terms of predicting lunch quality both in unadjusted models
160 with food groups only and in the model adjusted for all foods and nutrients were folate, vitamin C and
161 iron which were all associated with a consistent increase in DQS (see figure 1). For example, lunches with
162 the lowest quintile of folate provided in their lunch (1-31ug) on average had a score of less than 8
163 whereas lunches provided with the highest quintile of folate (75ug or more) on average had a score of
164 more than 12 (out of 21). The model with all 8 foods and these three nutrients explained 70% of the
165 variation in lunch quality score (see table 1). Higher provision of healthy foods such as sandwiches and
166 lower provision of restricted foods increased DQS significantly (see table 2). When the main models were
167 adjusted for energy the R squared values did not change (data not shown).

168 **DISCUSSION**

169 We found that meeting recommended levels of both foods and nutrients are necessary to ensure a high
170 quality packed lunch. However, the use of a large number of nutrient standards in addition to food based
171 standards is not welcomed by schools as has been seen for school meal standards where the nutrient
172 based standards have been replaced with the food based school food plan⁽⁹⁾. To improve policy guidelines
173 these results identify three key nutrients that are useful to incorporate with food based
174 recommendations into policies to encourage good quality packed lunches; namely folate, vitamin C and
175 iron.

176 These results indicate that for packed lunches, including healthy, and restricting unhealthy, foods
177 adequately ensures that macronutrients such as fats and added sugars are controlled. We found no
178 association with total fat provision and lunch quality and associations for saturated fat were weaker than
179 for other nutrients. Furthermore, added sugars were not associated with lunch quality when foods were
180 included since these are sufficiently limited through restriction of confectionery and drinks. Similar
181 findings have been reported for school meals in the school food plan. However, the addition of nutrient
182 standards to food standards is useful for ensuring a nutritious packed lunch rich in micronutrients. The
183 quality of packed lunches could improve if specific advice is provided on foods rich in folate, vitamin C and
184 iron in addition to the existing food based recommendations. This would include encouraging the
185 following: sandwiches with an iron rich filling such as red meat or beans/lentils, salad with green leaves,
186 citrus fruits and pure fruit juices. Dessert items that are not confectionery are already encouraged by

187 many schools such as promoting fruit based cakes without chocolate, e.g. apple cake and sweetened
188 bread based items that contain less sugar than cake such as teacakes.

189 Some nutrients may not have contributed to variation in lunch quality as they are highly correlated with
190 other nutrients. These include correlations between total fat and saturated fat; calcium with protein; zinc
191 and saturated fat; fibre and iron; protein and sodium (data not shown). This may explain why fibre was
192 not as strongly associated with lunch quality as expected. Lower sodium was associated with higher lunch
193 quality, however common sources of sodium are nutritious foods such as meat, fish, bread and cheese
194 and not from salt added to the packed lunch. Therefore reformulation of foods to reduce sodium content
195 is potentially more beneficial than individual advice.

196 There is little previous research with which to compare our results; a strength of this study. Previous
197 analysis comparing lunches that met only the food based standards and those that met both food and
198 nutrient based standards reported that lunches that met both were more nutritious⁽¹⁴⁾. Also a strength,
199 was the inclusion of a large representative sample of children from schools across the UK, although the
200 majority are from England. The clustering of children within schools is taken into account in the analysis
201 using a two level model. This research provides an ideal opportunity to build a DQS for food provided at
202 lunch time for children. However, there are limitations to this study. There is no universally agreed
203 measure of dietary quality for children's lunches and therefore the DQS is not in general use and has not
204 been validated. Indeed a review reported that there are many measures of dietary quality in use in
205 children⁽¹¹⁾. Furthermore the DQS is based on levels of nutrients and foods of interest, which is not ideal.
206 The majority of the nutrient standards are for nutrients that are encouraged rather than limited which
207 may bias assessment in favour of healthier components. This analysis only included children who took a
208 packed lunch to school and did not include children having a school meal for comparison. Also, the
209 analysis did not take into account differences in standards by region. Further work is required on school
210 meal data to determine whether similar patterns result. Although representative of 8 to 9 year olds, the
211 information is not necessarily relevant for other age groups. The focus of the analysis is dietary quality of
212 one meal event and not dietary quality over the whole day.

213 Despite these limitations, the information presented here is useful for school policy makers aiming to
214 improve the quality of packed lunches brought to school. The results from this analysis of packed lunches
215 reveal that including recommendations for a small number of nutrients namely folate, iron and vitamin C
216 in conjunction with the recommendations for foods, both encouraged and restricted, could help improve
217 packed lunch quality. Packed lunch policies are set by schools and therefore individual schools would be
218 responsible for evaluating the success of a policy; training relevant school staff and communicating
219 information to parents via websites or newsletters.

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Table 1: Percent of variation in dietary quality explained by different regression models with specified foods and nutrients. R squared denotes the overall variation explained by the model. The intra-class-correlation (ICC) denotes the percentage variation at the school level in the 2 level model. The remaining variation is at the individual lunch level.

Model name	Specific foods and nutrients included in the model	% Variation in dietary quality explained (R²)	ICC (%)
Full model	All 8 food groups and all 13 nutrients	73.7	4.2
Foods & significant nutrients	All 8 foods and statistically significant 7 nutrients (protein, vitamin C, iron calcium, sat fat, sodium, folate)	72.4	4.6
Foods only	All 8 food groups and no nutrients	62.4	5.0
Nutrients only	All 13 nutrients and no foods	62.5	6.0
Iron	Iron and all 8 food groups	66.7	5.3
Folate	Folate and all 8 food groups	66.4	5.8
Vitamin C	Vitamin C and all 8 food groups	65.6	4.6
Fibre (NSP)	Fibre and all 8 food groups	64.9	5.6
Protein	Protein and all 8 food groups	64.5	5.0
Zinc	Zinc and all 8 food groups	64.3	5.2
Carbohydrate	Carbohydrate and all 8 food groups	64.1	4.2
Calcium	Calcium and all 8 food groups	63.7	5.2
Vitamin A	Vitamin A and all 8 food groups	63.6	5.8
Total fat	Total fat and all 8 food groups	62.5	4.7
Saturated fat	Saturated fat and all 8 food groups	62.4	5.1
Sodium	Sodium and all 8 food groups	62.4	5.2
NMES	NMES and all 8 food groups	62.4	4.6
Food & 3 nutrients	Iron, folate, vitamin C, and all 8 food groups	69.8	4.4

Table 2: Mean and 95% confidence intervals of dietary quality score out of 21 for each quintile of 6 food groups; sandwich (low fat carbohydrate), fruit, milk dessert, savoury snacks, confectionery (sweet snacks) and sugar sweetened beverages (SSB) in children’s packed lunches. The multilevel model has been taken into account.

Food	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
	Mean score	95% CI	Mean score	95% CI	Mean score	95% CI	Mean score	95% CI	Mean score	95% CI
Sandwich	8.0	7.6, 8.4	9.3	9.0, 9.6	10.0	9.6, 10.4	10.5	10.1, 10.8	12.1	11.7, 12.5
Fruit	9.0	8.8, 9.2	9.0	8.8, 9.2	9.0	8.8, 9.2	10.8	10.5, 11.2	12.0	11.7, 12.3
Milk dessert	9.4	9.1, 9.7	9.4	9.1, 9.7	9.4	9.1, 9.7	10.4	10.1, 10.7	11.2	10.9, 11.5
Savoury snack	11.3	10.9, 11.6	11.3	10.9, 11.6	8.9	8.5, 9.2	9.7	9.0, 10.4	9.2	8.9, 9.5
Confectionery	11.2	10.9, 11.5	11.2	10.9, 11.5	9.3	8.9, 9.6	9.3	8.9, 9.8	9.0	8.7, 9.3
SSB	10.8	10.5, 11.2	10.8	10.5, 11.2	8.9	8.5, 9.2	9.5	9.2, 9.9	9.9	9.6, 10.2

Figure 1: Mean dietary quality score out of 21 for each quintile of the 4 nutrients: vitamin C, protein, iron and folate, provided in children’s packed lunches which improved dietary quality score in conjunction with food groups

