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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<sup>(1)</sup>. National age specific recommended levels of foods and nutrients are set by  
60 many countries in Europe,<sup>(2; 3)</sup> the USA<sup>(4)</sup> and Australia<sup>(5)</sup>. 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 <sup>(6; 7)</sup>. 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<sup>(8)</sup>. 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<sup>(9)</sup>. 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<sup>(10)</sup>.

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<sup>(11)</sup>. 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<sup>(12)</sup>.

79 The European Commission has recently published a report on the 34 school food policies in 30 countries  
80 in Europe <sup>(13)</sup>; Out of the total, 31 policies included food based standards and 23, nutrient based  
81 standards<sup>(13)</sup>. 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 <sup>(14)</sup> 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<sup>(15; 16)</sup>.

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<sup>(17)</sup>. 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 6<sup>th</sup> edition of  
104     the composition of foods<sup>(18)</sup>. 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.<sup>(19)</sup> 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<sup>(15)</sup>. 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

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

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

## DISCUSSION

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

These results indicate that for packed lunches, including healthy, and restricting unhealthy, foods adequately ensures that macronutrients such as fats and added sugars are controlled. We found no association with total fat provision and lunch quality and associations for saturated fat were weaker than for other nutrients. Furthermore, added sugars were not associated with lunch quality when foods were included since these are sufficiently limited through restriction of confectionery and drinks. Similar findings have been reported for school meals in the school food plan. However, the addition of nutrient standards to food standards is useful for ensuring a nutritious packed lunch rich in micronutrients. The quality of packed lunches could improve if specific advice is provided on foods rich in folate, vitamin C and iron in addition to the existing food based recommendations. This would include encouraging the following: sandwiches with an iron rich filling such as red meat or beans/lentils, salad with green leaves, 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<sup>(14)</sup>. 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<sup>(11)</sup>. 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 (R <sup>2</sup> )	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	8.8, 9.6
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	8.6, 9.4
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

