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A repeated cross-sectional survey assessing changes in diet and nutrient quality of English primary school children's packed lunches between 2006 and 2016

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ABSTRACT

Objective Mandatory school meal standards were introduced in 2006 in England; however, no legislation exists for packed lunches. This study analyses provision of foods and nutrients in packed lunches in 2016 to highlight differences in diet and nutrient quality since 2006.

Design Two cross-sectional surveys of children's packed lunches were conducted in 2006 and 2016. Data were analysed using multilevel regression models taking into account the clustering of children within primary schools.

Setting Data were collected from 1148 children who attended 76 schools across England in 2006 and from 323 children attending 18 schools across England in 2016.

Participants Children were included if they regularly ate a packed lunch prepared at home (approximately half of children take a packed lunch to school) and were aged 8–9 years (in year 4), for both surveys.

Outcome measures Data collected in both years included provision of weight and type of food, nutrients and proportion of lunches meeting individual and combined school meal standards.

Results Frequency of provision and portion size of some food types changed substantially between surveys. Frequency of provision of confectionery in lunches reduced by 9.9% (95% CI −20.0 to 0.2%), sweetened drinks reduced by 14.4% (95% CI −24.8 to −4.0%), and cakes and biscuits not containing chocolate increased by 9.6% (95% CI 3.0 to 16.3%). Vegetable provision in lunches remained low. Substantial changes were seen in the percentage of lunches meeting some nutrient standards: non-milk extrinsic sugars (19%, 95% CI 10 to 29%), vitamin A (−8%, 95% CI −12 to −4%), vitamin C (−35%, 95% CI −42 to −28%) and zinc (−8%, 95% CI −14 to −1%).

Conclusions Packed lunches remain low quality with few meeting standards set for school meals. Provision of sugars has reduced due to reductions in provision and portion size of sugary drinks and packaged sweet foods; however, provision of some nutrients has worsened.

Strengths and limitations of this study:

- This repeated cross-sectional survey provides a unique opportunity to highlight changes in the quality of children's packed lunches over 10 years in England
- Food was weighed whenever possible to enable accurate dietary assessment of food provided and consumed
- A limitation of the study is that data were only collected on one day.
- We did not collect data over the whole day so we have no information on what children were eating outside school

INTRODUCTION

Childhood obesity is a global problem described as one of the most serious challenges to public health in the 21st century.[1] Rates continue to rise across the globe[2] and the UK is no exception. In 2015 over a third of British 10 year olds were overweight or obese[3] and children living in disadvantaged areas are at double the risk of obesity.[3] Childhood obesity is linked to increased school absenteeism,[4] low performance in assessments[5] and increased prevalence of chronic illnesses such as asthma,[6] and diseases in adulthood such as obesity,[7] type two diabetes,[8] cancer[9] and cardiovascular disease.[10] Many of the causal factors for childhood obesity relate to food consumption and energy expenditure, and extrinsic factors such as availability, accessibility, portion size and the effect of food advertising.[11 12] WHO recommends that children consume a high-quality diet rich in fruit and vegetables and low in foods containing high levels of free sugars and saturated fats and salt.[1]

Improving the school food environment could effectively reduce childhood obesity risk,[13] particularly when combined with improved physical activity.[14] In the UK,

children either have a school meal (usually hot) prepared at school or take a packed lunch to school that is prepared at home usually by parents or carers with varying input from children. Approximately half of primary school children have a school meal and half take in a packed lunch.[15] Research has shown that a nutritious school meal not only improves lunchtime intake but also children's overall diet quality in England,[16] including children from low-income households.[17] Since 2006, measures have been implemented to improve school meals in England. The standards set out in the School Food Plan[18] require schools to follow School Food Regulations.[19 20] New food-based standards are detailed in the School Food Plan,[21] but nutrient-based standards were dropped as they were deemed too difficult to use effectively in schools. Confectionery, savoury snacks and sugar-sweetened beverages (SSBs) are restricted, while fruit, vegetables, low-fat starch, protein and dairy are required to be included at each meal. However, no regulatory legislation exists for packed lunches and because more than half of children take a packed lunch to school[22] these meals represent a significant contribution to the diet quality of children. Research consistently shows that primary school children's packed lunches are of inferior quality compared with school meals both before[23] and after[24] the introduction of standards because on average they contain higher levels of sweetened foods and drinks, savoury snacks, fats and salt, and lower levels of fibre, protein, vegetables and water.[16 25]

Improving the quality of children's packed lunches to reduce the discrepancy between school meals and packed lunches is clearly important. A large cross-sectional survey of British children's packed lunches carried out in 2006 reported that only 1% met all eight of the food-based standards for school meals.[26] None of the lunches met all the nutrient-based standards introduced in 2006, which have since been dropped. Levels of non-milk extrinsic sugars (NMES) were found to be particularly high because of the provision of SSBs in two out of three packed lunches and energy-dense snacks in four out of five. Only one in five children had vegetables or salad in their packed lunch. Interventions to improve packed lunches have had some success, such as the Smart Lunchbox programme which was implemented in schools across the UK over several months. The programme increased both portion size and frequency of provision of fruits, vegetables and dairy, and reduced savoury snacks[27]; however, it had no impact on reducing sugary drinks or foods. In Denmark, replacing standard packed lunches with lunches based on the 'New Nordic Diet' for Danish children also saw moderate improvements, with a 16% increase in vegetable intake and a 6% reduction in fats reported.[28]

This survey aims to assess whether the diet and nutrient quality of children's packed lunches has improved from 2006 to 2016 and to assess whether these differences are because of frequency or portion size of specific types of food.

METHODS

All English schools who previously participated in the survey of packed lunches in 2006[26] and are currently operational were contacted and asked to take part in the repeat survey in 2016. Additional information is available on the original methods.[27] It was anticipated that only a proportion of the original sample would agree to participate and therefore a second stage of recruitment was planned by the National Foundation of Educational Research (NFER). All non-fee paying primary schools in England were eligible. Ethical approval was granted by the University of Leeds (MEEC15-031), with participants only recognised using an identification number. Opt in consent was required from schools and opt out consent was used for pupils.

Patient and public involvement

There was no public involvement directly related to this analysis, although focus groups were carried out with parents and children (unpublished) and qualitative process measures were collected from teachers and children[29] as part of the original packed lunch trial.[27]

Recruitment of primary schools in 2016

The schools that took part in the original study were contacted by mail and again by email twice, and by phone twice if they did not reply. The second wave of recruitment undertaken by NFER involved randomly selecting 75 schools by using their register of schools and sending an initial invitation letter and reply form. The sample was stratified by region to ensure a nationally representative spread. A reminder letter and reply form were sent to any schools that did not respond, with a follow-up phone call made to those from whom responses still had not been received; a final email was sent to schools that could not be contacted by phone. Schools provided data for the pupils in year four classes who had packed lunches and details of the school's packed lunch policy.

Sample size calculation

The sample size is based on children clustered within schools. Children in the same cluster (school) tend to be correlated (and therefore non-independent). This means a larger number of children are needed to have the same power compared with studies where there are no clusters. The intraclass correlation coefficient is the proportion of the total variance that can be explained by the variation between clusters. The sample size was calculated by assuming an intraclass correlation of 0.02 from previous research on packed lunches[26] and using data from the UK National Diet and Nutrition Survey rolling programme (NDNS-rp).[30] The initial lunchbox survey found a typical number of children taking packed lunches to school was 12 per class (classes generally include 25–30 pupils). To have 90% power to detect a difference in percentage energy from saturated fat (SD=3) of 1% from 13% to 12% would require 230 children to complete the survey.

Data collection

The survey period was from 20 June to 1 July 2016, the same time of year that data were collected in 2006. In 2016, data on packed lunches were collected by six trained administrators employed by NFER on a single day for each school. Administrators were provided with weighing scales and disposable gloves, and attended one day of training to help them recognise different types of foods and drinks commonly provided in children's packed lunches.

Administrators took children aside individually and worked through a standard questionnaire (see online supplementary material), detailing the foods within the lunchboxes. Food portions were weighed before and after lunch to determine exactly how much food each child ate and its nutritional content. The questionnaire was similar to the one used in 2006 with some amendments. The questionnaire was split into foods that met the school food-based standards (for example, protein and carbohydrate sources) and those that did not (confectionery and savoury snacks). Certain snacks that are nutritionally similar were amalgamated. The final section of the questionnaire was split into sweet snacks that met the school food-based standards and those that did not meet the standards. For example, cereal bars, flapjack (oat-based cereal bars) and sponge cake or bars were split into plain versions without chocolate and chocolate versions so that results could differentiate between those that met the school meal standards and those that did not.

Information was collected on the weight of foods provided and consumed, and on food types. Foods where the container weight was unknown were assigned a predetermined average weight for the container of 25 g. In addition, drinks were checked to ensure that any child bringing water to school had a weight of water and those having school water had that box ticked. Each pupil had two food records, one for the food provided and one for food left over; food consumed was calculated from food provided minus leftover food and is reported separately. Data were entered into myfood24 and Excel by a trained coder and checked by a second coder to improve data accuracy. Dietary data were analysed using myfood24,[31] which contains nutrient data for thousands of foods, generic and branded. Originally based on the sixth edition of the composition of foods,[32] which was released in 2002, myfood24 was updated in 2017 for this analysis with the seventh (most recent) edition released in 2014.[33] The nutrient analysis was run from myfood24 and data were extracted into Excel and Stata.

Data analysis

The analysis was carried out using StataIC 14. Analyses were conducted according to a predetermined analysis plan used in the original 2006 survey (unpublished), with additional objectives related to comparisons between the two surveys. The schools were described in terms of mean percentage eligibility for free school meals (%FSM), a proxy for socioeconomic position of the pupils, and percentage meeting expected academic standards. The diet-related data are presented in terms of foods, food groups, nutrients and adherence to standards set for school meals. The foods provided in each child's packed lunch were categorised according to the foods included in the standards for school meals (permitted or restricted) set out in the School Food Plan.[18] The school meal standards include recommendations on eight different types of food. Five food types are encouraged: protein-rich foods, low-fat starchy food, dairy food, fruit and vegetables; and three food types are restricted: sweetened drinks, confectionery (chocolate-based sweet snacks) and savoury snacks (such as crisps). Desserts were split into three categories: those that contained milk such as yoghurts and meet the standards for school meals; those that did not contain milk but also did not contain chocolate such as flapjack and plain biscuits (also permitted in school meals); and those that contain chocolate and were therefore categorised as confectionery and do not meet the standards. Drinks were also split into different categories: those that are permitted (water, milk, pure fruit juice); and those that are restricted (sweetened squashes, low-calorie soft drinks).

Mean weights of foods were calculated using two different methods. First, the mean weights of foods provided for the whole sample of children were calculated; second, the mean weights of foods were calculated for only the children eating that food type, thereby providing the portion size weight of each food type provided to children. The percentage of lunches that met the food-based standard for school meals for each food group is reported. The number and percentage of children who met each of these eight individual standards were calculated. Additionally, the number and percentage of children who met the five healthy standards and the number and percentage who met all eight standards were calculated. The levels of nutrients were reported for the 13 nutrients plus energy that were included in the original school meal nutrient-based standards. The amount of each nutrient is reported with the percentage meeting the nutrient standard for school meals.

Results from the 2006 survey (England only) are included for comparisons between years. Regression models were used to compare the results for foods, food groups and nutrients in 2016 compared with the results from 2006. A model was run for each food and nutrient, with food or nutrient as the outcome variable and the year as the predictor variable. Multilevel modelling was used in all analyses to take account of the fact that children are clustered within schools and children within a school may be more similar to each other than children in another school. This enables appropriate standard errors of the coefficients to be calculated. Random intercept models were used, with foods and nutrients as the outcome variables.

Table 1 The prevalence of the most common foods of each type provided in English children's packed lunches in 2006 and 2016 (percentage of 1148 lunches in 2006 and percentage of 323 lunches in 2016)

Food type	Most common examples 2006	Most common examples 2016
Sandwich bread type	White sliced (37), white rolls (15), high-fibre white bread (10)	White sliced (34), tortillas (13), white rolls (10), high-fibre white bread (4)
Sandwich fillings	Ham (27), cheese (12), chicken (11), tuna (7), jam (9)	Ham (28), cheese (18), chicken (9), tuna (9), Nutella (7)
Fruit	Apple (20), grapes (9), banana (9), orange (9), raisins (4)	Apple (18), grapes (11), banana (9), raisins (9), orange (7)
Vegetables	Cucumber (8), tomatoes (7), lettuce (2), carrots (3)	Cucumber (10), tomatoes (6), lettuce (3), carrots (2)
High fat savoury foods	Sausage, for example, Peperami (6), sausage roll (5)	Sausage, for example, Peperami (9), sausage roll (5)
Cheese (outside sandwich)	Cheese string (6), cheese dip (3), Edam (3)	Cheese string (13), Edam (7), cheese dip (1)
Milk-based desserts	Fromage frais (19), yoghurt (11), drinking yoghurt (4)	Yoghurt (27), fromage frais (10), drinking yoghurt (7)
Savoury snacks	Crisps (31), corn-based snacks (11), potato starch rings (11)	Crisps (28), potato starch rings (17), corn based snacks (11)
Confectionery	Chocolate biscuit (28), sweets/chocolate (11), chocolate cake/cereal bar (19)	Chocolate biscuit (34), sweets/chocolates (12), chocolate cake/cereal bar (11)
Permitted desserts	Plain biscuits (5), flapjack (4)	Plain biscuit (10), flapjack (4)
Sweetened drinks	Sweetened squash (36), fruit drink carton (23)	Sweetened squash (27), fruit drink carton (12)
Permitted drinks	Water (14), pure juice (14)	Water (16), pure juice (14)

RESULTS

Six schools included in the original survey in 2006 had closed, leaving a potential study sample of 70 schools in England to be re-contacted. The first wave of recruitment for the 2016 survey by the University of Leeds recruited 12 schools that had participated in the original 2006 baseline study. The second wave of recruitment, undertaken by the NFER, resulted in a further eight schools agreeing to take part. This resulted in a total sample size of 20 schools. Later, at the point of data collection, a further two schools dropped out of the study. The final number of children was 323 in 18 English schools in 2016 and 1148 in 76 English schools in 2006. School-level factors such as %FSM were close to national averages for England in both years. In 2006, %FSM in the sample and nationally was 16% and 15%, respectively. In 2016, the metric used by the Department of Education was changed slightly to %FSM over the past six years, and the sample and national means were 24% and 25%, respectively. In 2006, the schools were similar to the UK average in terms of academic achievement, as previously reported[34]; in 2016 the mean percentage meeting expected standards was 53% compared with the national mean of 58%.

The most commonly provided foods in children's lunches in 2006 and 2016 (see table 1) are comparable in both years. Types of bread had changed and tortillas or wraps were much more popular, with 13% of children being provided with these items in their lunch in 2016 but only 2% in 2006. The most common sandwich filling for children was still ham. Some children had a sandwich filling that was very low in protein, such as jam or marmite. Very few children had a plant-based sandwich filling such as hummus and vegetable spreads, which made up less than 1% of sandwich fillings.

Weights, proportions and portion sizes of foods

The largest component by weight of a packed lunch is typically a sandwich, which can vary in quality in terms of bread type and filling. Mean weights provided were similar between 2006 and 2016 for most foods (see table 2), but decreased for some foods such as milk-based desserts, confectionery and sweetened drinks. Permitted desserts such as plain biscuits and flapjack increased in weight.

The percentage of children provided with three food types changed substantially between 2006 and 2016 (see table 2): confectionery reduced by 9.9% (95% CI −20.0% to 0.2%), sweetened drinks reduced by 14.4% (95% CI −24.8% to −4.0%) and non-chocolate cakes and biscuits increased by 9.6% (95% CI 3.0% to 16.3%). Other food types were provided to approximately the same degree. Vegetable provision in lunches remained low and were the least common foods included in children's packed lunches. In 2016 there were 74 (23%) children who did not bring a drink from home. It is assumed that most of these children would have consumed water available at school, but it is possible that some children did not consume a drink.

Food portion sizes decreased for six foods (see table 2), including fruit (−15 g), cheese snacks (−14 g), milk-based desserts (−21 g), confectionery (−6 g), permitted cakes and biscuits (−13 g), and sweetened drinks (−56 g). No foods had a substantially increased portion size.

Table 2 Children provided with each food type (number and %) and mean weight and 95% CI of each food type provided in packed lunches in 2006 for 1148 children and in 2016 for 323 children (total of 1471 English children with results adjusted for school clusters)

Food type	Provided 2006, % (n)	Provided 2016, % (n)	Difference (p value)	Mean weight provided 2006 (g)	95% CI	Mean weight provided 2016 (g)	95% CI	Mean portion size 2006 (g)	95% CI	Mean portion size 2016 (g)	95% CI	Difference in portion size (g)	95% CI (p value)
Sandwich	85 (978)	83 (267)	2.5 (0.349)	95.7	91.5 to 99.7	91.9	78.5 to 105	112	109 to 116	111	100 to 121	–0.1	–1.2 to 0.9 (0.829)
Permitted savoury food	n/a	10 (31)	n/a	n/a	n/a	11.7	–2.1 to 25.6	n/a	n/a	122	1.9 to 242.9	n/a	n/a
High-fat savoury food	14 (165)	14 (44)	–0.8 (0.692)	12.8	10.0 to 15.6	10.9	7.6 to 14.2	89.0	72.4 to 105.5	80.2	57.5 to 102.8	–8.8	–36.2 to 18.6 (0.525)
Vegetables/ salad (any)	20 (233)	20 (66)	0.1 (0.959)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Vegetables/ salad (outside sandwich)	11 (130)	10 (33)	–1.1 (0.660)	7.0	5.2 to 8.8	7.7	4.9 to 10.5	63.3	55.2 to 71.5	75.3	50.1 to 100	12.0	–11.5 to 35.4 (0.312)
Fruit	54 (621)	57 (185)	3.2 (0.397)	69.5	61.7 to 77.4	66.5	55.8 to 77.2	131	124 to 137	116	104 to 128	–14.8	–26.8 to –2.9 (0.016)
Cheese snacks	18 (202)	20 (63)	1.9 (0.510)	7.1	5.7 to 8.6	5.6	3.8 to 7.4	42.4	37.1 to 47.7	28.8	25.2 to 32.3	–13.7	–19.9 to –7.4 (<0.001)
Milk-based desserts	47 (537)	42 (137)	–4.5 (0.379)	39.2	35.3 to 43.0	27.7	19.8 to 5.5	86.0	81.5 to 90.5	65.2	58.6 to 71.9	–20.7	–28.2 to –13.3 (<0.001)
Savoury snacks	61 (697)	60 (195)	–0.3 (0.936)	16.6	15.3 to 17.9	15.7	13.3 to 18.0	27.3	26.1 to 28.5	26.0	24.4 to 27.5	–1.4	–3.2 to 0.5 (0.146)
Confectionery	62 (707)	52 (167)	–9.9 (0.055)	22.7	20.8 to 24.7	16.2	12.9 to 19.5	36.9	34.8 to 39.1	31.4	29.1 to 33.6	–5.5	–8.6 to –2.5 (0.001)
Permitted cakes and biscuits	15 (170)	24 (79)	9.6 (0.005)	7.4	5.8 to 9.0	9.2	6.5 to 11.9	50.1	44.6 to 55.7	37.4	33.7 to 41.1	–12.7	–18.9 to –6.5 (<0.001)
Sweetened drinks	60 (693)	46 (149)	–14.4 (0.007)	213	195 to 231	137	107 to 167	353	338 to 369	298	264 to 332	–55.5	–90.0 to –21.0 (0.002)
Permitted drinks	29 (338)	31 (100)	1.4 (0.711)	101	87.4 to 114	99.8	70.5 to 127	342	323 to 362	320	282 to 358	–22.2	–63.3 to 18.8 (0.284)

Table 3 Comparison of lunch box food items provided in 2016 and 2006, with school meal food-based standards for England (total of 1471 children with results adjusted for school clusters)

Food group standards met	School meal standard	Meeting standard 2006 (n)	Meeting standard 2006 (%)	Meeting standard 2016 (n)	Meeting standard 2016 (%)	Difference in %	95% CI for difference (p value)
All food standards		12	1.1	5	1.6	0.5	−1.1 to 2.1 (0.527)
Five healthy food groups included		69	6.0	18	5.6	−0.4	−3.9 to 3.1 (0.804)
No restricted foods included		97	8.5	23	16.4	8.0	6.7 to 15.2 (0.033)
Individual healthy food groups Included							
Starch	Included	1004	87	271	84	−3.6	−8.8 to 1.6 (0.177)
Protein	Included	833	73	248	77	4.2	−2.7 to 11.1 (0.228)
Fruit	Included	621	54	185	57	3.2	−4.2 to 10.6 (0.397)
Dairy	Included	635	55	168	52	−3.3	−12.4 to 5.8 (0.473)
Vegetables	Included	233	20	66	20	0.1	−5.2 to 5.5 (0.959)
Individual restricted items excluded							
Confectionery	Excluded	441	38	156	48	9.9	−0.2 to 20.0 (0.055)
Sweetened drink	Excluded	455	40	174	54	14.2	3.8 to 24.7 (0.008)
Savoury snack	Excluded	451	39	128	40	0.3	−8.1 to 8.8 (0.936)

Food standards

The percentage of children's packed lunches meeting all eight standards (provision of five healthy food groups and restriction of three unhealthy food groups) increased slightly but not significantly from 1.1% to 1.6% (see table 3). The percentage of lunches meeting the five healthy standards also did not change between 2006 and 2016. However, the percentage of lunches that did not contain any of the restricted foods increased from 9% to 16% (difference of 8%, 95% CI 6.7% to 15.2%). This was mainly due to reductions in sugary drinks and also reductions in confectionery. Provision of savoury snacks such as crisps did not change between 2006 and 2016. There were lunches that included all three restricted foods and drinks and the proportion of these reduced from 26.8% in 2006 to 21.4% in 2016.

Good and poor examples of packed lunches

Three lunches in 2016 did not meet any of the standards and therefore had a score of zero. They contained a sugary drink, a savoury snack and a chocolate bar. One also contained a high-fat savoury food (see lunch 4 in table 4). The five best quality packed lunches in 2016

Table 4 Descriptions of high-quality (lunches 1, 2 and 3) and low-quality (lunch 4) packed lunches in 2016

Food groups	Lunch 1	Lunch 2	Lunch 3	Lunch 4
Low-fat starch	Bread	Bread	Bread	None
Protein	Chicken	Egg mayo	Ham	Pasty
Vegetables	Cucumber and pepper	Tomato	Tomato	None
Fruit	Grapes	Orange	Raisins	None
Dairy	Yoghurt	Yoghurt and drinking yoghurt	Yoghurt	None
Other food items	Water	Water	Sponge cake, water	Squash, crisps and chocolate bar

were made up entirely of recommended foods and no restricted foods; three of these are summarised in table 4.

Nutrient levels and standards in children's packed lunches

There were a number of changes in nutrient provision between 2006 and 2016 (see table 5). Some of these were indicative of improved quality in packed lunches, such as the reduction in NMES from 40 g to 24 g, but some essential micronutrients had also decreased, such as mean vitamin C reducing from 58 mg to 30 mg. More than half of children met the nutrient-based standards that were historically set for school meals for protein, total fat, total carbohydrate and calcium, but few children met the standards for fibre, vitamin A, iron or zinc. Levels of saturated fats, NMES and salt in children's packed lunches also continue to be higher than recommended. The most substantial differences in percentage of lunches meeting individual nutrient standards between 2006 and 2016 were energy (−4%), total carbohydrate (−13%), NMES %E (−18%), vitamin A (−8%), vitamin C (−35%) and zinc (−8%).

The standard for energy is unique in that the standard contains both a lower and an upper limit; very few children met the standard for energy due to energy provided being too low or too high. Nevertheless, there was a decrease in the overall provision of energy from 625 to 591 kcal, resulting in 4% more meals not meeting the food standard because they were too low in energy.

DISCUSSION

This is the first analysis of children's packed lunches that directly compares data from two separate but repeated surveys 10 years apart. The largest differences in foods provided in lunches between 2006 and 2016 were the reductions in frequency and portion size of sugary drinks and confectionery. The proportion of children provided with a sugary drink dropped from 60% to 46% and the proportion having confectionery dropped from 62% to 52%. Provision of non-chocolate-based cakes and biscuits increased but portion size decreased, as did portion size of dairy foods. There were no substantial changes in the frequency or portion size of savoury snacks or vegetables.

The main improvements in nutritional quality of packed lunches were the decreases in levels of NMES and the concomitant increase in the proportion of lunches meeting the NMES standard. However, there were no reductions in saturated fats, and levels of some essential nutrients decreased in 2016, leading to smaller proportions of lunches meeting the standards for vitamin A, vitamin C and zinc. The proportion meeting the standard for iron was low in both years. Low vitamin and mineral levels are most likely due to the lack of fresh food in the children's packed lunches, such as salad and vegetables and unprocessed meat or fish, as well as a lack of wholegrain carbohydrate sources.

Although NMES have decreased in children's lunches in the past 10 years, the levels provided remain higher than recommended due to the predominance of sweet foods and drinks, with two-thirds of lunches exceeding the standard. However, further reductions in NMES content of sugary drinks are likely to have occurred since 2016 when it was announced that a soft drinks industry levy (SDIL) would be implemented in April 2018.[35] Many drinks manufacturers reduced sugar levels or switched to low or no-sugar versions between 2016 and 2018 in the UK. The largest differences in portion size were reductions in sweetened drinks and milk based desserts (such as yoghurts and fromage frais), which reduced from 338 to 298 ml and from 87g to 65 g, respectively. The portion size of confectionery also reduced from 37 to 31 g. These reduced portion sizes of foods that are usually bought in discrete packages are most likely reflective of changes that have occurred in the food industry. Providing portion sizes in supermarkets that are appropriate for all ages is difficult,[36] but portion size reduction in chocolate confectionery has been a key part of the Public Health England calorie reduction strategy from the Responsibility Deal calorie reduction pledge in 2011[37] to reduce free sugars.[38] The recommendation for free sugars is challenging to meet but is possible if children have water or a sugar-free drink, and only small portions of sweet foods. A chocolate or plain biscuit weighing 25 g plus a sweetened yoghurt weighing 75 g contain approximately 15 g of free sugars, which is within the recommended levels for a child's lunch, although this does not take into account any contributions from additional sources. No such reduction in portion size was seen for crisps, perhaps indicative of the lack of focus on reformulation and portion size reduction for savoury snacks in comparison to sweet snack food categories.

The smaller portion sizes of cheese and yoghurt in 2016 are more appropriate for this age group of 8–9 year olds compared with the 2006 results in terms of contribution of fats and sugars and provide enough calcium to meet the calcium standard of 193 mg. However, many children did not have any dairy foods included in their lunch and therefore did not meet the standard set for calcium. The reduction in portion size of fruit provided is also worrying as fruit is a major source of essential nutrients, including vitamin C and vitamin A, which have both reduced between 2006 and 2016. It is not clear why the amount of fruit provided has decreased. For those children provided with vegetables the amount was around the recommended portion of 75 g, however only 20% of children were provided with any vegetables.

While changes in lunch quality due to changes in portion size were possible to evaluate, changes due to reformulation were more difficult to estimate. The Royal Society of Chemistry analyse a range of foods at regular intervals approximately once a decade. The sixth edition of the Composition of Foods was published in 2002 and the seventh edition in 2014. Small reductions in fats, sugars and salt were seen when levels were analysed with 2014 data compared with 2002 data (data not shown here). These differences are most likely due to reformulation.

Table 5 Levels of nutrients provided in 2006 and 2016 and comparison of nutrients provided with historical school meal nutrient-based standards. Difference is percent difference of lunches meeting standard in 2016 compared with 2006. The sample includes 1148 English children in 2006 and 323 English children in 2016 (with results adjusted for school clusters)

Nutrient (units)	School meal standards for England	Mean provided 2006	95% CI 2006	Meeting standard in 2006 (%)	Mean provided 2016	95% CI 2016	Meeting standard in 2016 (%)	Difference 2016–2006 (%)	95% CI of difference	P value of difference
Energy (kcal)	530	626	609 to 643	12	591	545 to 637	9	−3.8	−8.0 to 0.4	0.075
Protein (g)	7.5	18.1	17.5 to 18.7	94	18.5	16.6 to 20.5	94	0.1	−03.4 to 03.3	0.983
Total fat (g)	20.6	21.0	20.1 to 21.9	54	21.8	20.1 to 23.6	52	−2.7	−9.9 to 4.5	0.452
Saturated fat (g)	6.5	8.2	7.8 to 8.6	42	8.0	7.3 to 8.8	48	5.2	−2.4 to 12.8	0.178
Saturated fat (% E)	≤11	11.4	11.1 to 11.8	49	12.0	11.3 to 12.6	46	−2.2	−8.4 to 3.9	0.473
Total carbohydrate (g)	70.6	96.4	93.6 to 99.1	78	85.4	78.4 to 92.4	64	−13.4	−22.0 to −4.8	0.003
Total sugar (g)	n/a	50.3	48.1 to 52.5	n/a	36.3	31.9 to 40.6	n/a	n/a	n/a	n/a
NMES (g)	15.5	39.5	37.6 to 41.3	18	24.0	20.3 to 27.7	37	19.3	9.9 to 28.6	<0.001
NMES (% E)	≤11	24.9	23.9 to 25.9	17	15.6	14.0 to 17.2	31	18.4	10.7 to 26.2	<0.001
NSP (g)	4.2	3.6	3.4 to 3.8	32	3.8	3.4 to 4.1	32	0.3	−9.0 to 9.5	0.955
Sodium (mg)	499	869	833 to 905	20	797	721 to 873	20	0.5	−6.5 to 7.6	0.877
Vitamin A (µg)	175	160	144 to 176	24	112	92 to 133	16	−8.0	−12.4 to −3.5	0.001
Vitamin C (mg)	10.5	57.9	53.3 to 62.5	84	30.3	22.4 to 38.1	49	−35.1	−41.9 to −28.4	<0.001
Folate (µg)	53.0	76.9	64.3 to 89.5	43	57.0	49.3 to 64.7	41	−1.5	−9.0 to 6.0	0.683
Calcium (mg)	193	277	265 to 288	64	267	242 to 292	65	1.4	−8.5 to 11.3	0.778
Iron (mg)	3.0	2.44	2.36 to 2.53	24	2.50	2.28 to 2.72	23	−1.6	−9.4 to 6.2	0.686
Zinc (mg)	2.5	2.1	2.0 to 2.2	28	1.9	1.7 to 2.1	20	−7.5	−14.1 to −0.9	0.027

NMES, non-milk extrinsic sugar; NSP, non-starch polysaccharide.

Some city councils in the UK, Leeds for example,[39] strongly encourage local schools to have a packed lunch policy and offer training and resources to help head teachers to restrict intake of sugary drinks, confectionery and savoury snacks in packed lunches. However, there is likely to be huge variation in implementation and schools with head teachers passionate about providing a healthy food environment are likely to have achieved more in this area.[18] A national legislated policy would go a step further to ensure consistency across schools. Provision of fruit and particularly vegetables, which has not improved over the past 10 years,[40] is stubbornly low. Policies to increase fruit and vegetables and water consumption are critically needed. Providing free salad vegetables at primary schools for those having packed lunches may be one way to achieve this. Encouraging all children at school to drink water is also recommended. Educational activities for parents and children are important, but need to be part of a wider package, as information or education for parents on its own is unlikely to make a sustained difference.[34] A good example of engaging parents is through the use of social media; one Australian study reported improvements in diet quality of lunchboxes.[41] A recent systematic review of interventions to improve quality of packed lunches included 10 programmes mainly from the UK, the USA and Australia. The review reported modest improvements in fruit and vegetable content, but recommended environmental-based policies rather than relying on families alone.[42] Time constraints are likely to play a key role in the type of food provided in a child's lunchbox, with packaged convenience foods very common.[17 26 43] Therefore, efforts from industry to develop more 'lunchbox friendly' convenience packaged foods that are healthier and more vegetable based may also be an effective approach. More fruits and vegetables could be incorporated into other foods such as cakes and yoghurts, and portion sizes of savoury snacks reduced to prevent children filling up on more appealing foods and refusing nutritious elements such as their sandwich. Substantial improvements are needed to improve school food at lunchtime in order to have an impact on children's health including obesity. A recent review of school-based interventions and policies found modest improvements in lunchtime intake but no perceptible improvements in adiposity.[44]

A strength of the study was the broadly consistent approach taken for each survey, conducted by the same research team who weighed the majority of foods provided and left over in children's packed lunches. The analysis took into consideration the clustering of children within schools and the findings show the most common lunch items provided, which could help industry develop healthier 'lunchbox friendly' products. Although the two surveys were not directly comparable, both surveys recruited a sample of schools representative of primary schools in England in terms of socioeconomic profiles and collected data on different days of the week. Limitations included the cross-sectional nature of the study. Efforts were made to reduce bias by returning to the same schools, although too few schools took part in both surveys to rely solely on this method. Another weakness was the limited information collected on socio-demographic variables of individuals. This resulted in very low drop-out rates but meant it was not possible to determine whether it was a nationally representative sample based on individuals as well as schools or to analyse the data in terms of levels of deprivation. Furthermore, dietary assessment software is a source of error because it relies on food composition data that may have been collected 10 years previously and therefore does not reflect current food composition. This is particularly the case for foods that are being reformulated, such as sugary drinks and bread, where sugars and salt are gradually being reduced, implying that NMES and sodium could have been overestimated. However, fats are likely to be underestimated as children did not always know if and what type of spread was in their sandwich. Furthermore, it is likely that there were errors produced when estimating component weights of sandwiches, such as salad vegetables provided within a sandwich. In terms of the analysis, a limitation was the presence of multiple testing with a wide range of different foods and nutrients which could result in random error and findings being falsely reported as statistically significant. Finally, only one day of data were collected and children's packed lunches may vary daily.

CONCLUSION

Although some children's packed lunches contain healthy foods, packed lunches continue to be dominated by sweet and savoury snack foods and sugary drinks. A minority of children eat vegetables or salad and this has not changed in the past 10 years. Although not directly comparable, results from this 2016 survey confirm that children's packed lunches have improved in terms of levels of sugars provided, but continue to contain levels of saturated fat, added sugars and sodium that exceed current standards and recommendations. Further reductions in portion size of energy-dense food and reductions in the number of children taking a sugary drink to school rather than consuming water are welcomed. It is recommended that primary schools have a policy restricting sweetened drinks and strongly encourage water, fruits and salad. Improving the quality of children's packed lunches is a complex issue which needs strong support from many stakeholders, including government, industry and schools, if packed lunch quality is to improve in the next 10 years.

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