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Measures of low food variety and poor dietary quality in a cross-sectional study of London school children

CEL Evans[1]*, J Hutchinson[1]*, MS Christian[2], N Hancock[1], JE Cade[1]

Authors (last name underlined):

[1]Charlotte E.L. Evans: PhD, lecturer in Nutritional Epidemiology and public health nutrition, email: c.e.l.evans@leeds.ac.uk

[1]Jayne Hutchinson: PhD, Post-doctoral Research Fellow, email: j.hutchinson1@leeds.ac.uk

[1,2]Meaghan S Christian: PhD, Post-doctoral Research Fellow, email: mschristian@leedsbeckett.ac.uk

[1]Neil Hancock: Database Manager, email nhancock@leeds.ac.uk

[1]Janet E. Cade: PhD, Professor in Nutritional Epidemiology, email: jecade@leeds.ac.uk

Addresses:

[1]Nutritional Epidemiology Group, School of Food Science & Nutrition, University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, UK (CELE, JH, MSC, NH, JEC)

[2]School of Health and Wellbeing, Faculty of Health and Social Sciences, Leeds Beckett University, City Campus, Calverley Street, Leeds, LS1 3HE (MSC)

*Joint first authors

Correspondence to:

Charlotte E.L. Evans

Nutritional Epidemiology Group, School of Food Science & Nutrition, University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, UK

email: c.e.l.evans@Leeds.ac.uk

Telephone: 0113 343 3956

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Abbreviations:

BMI – Body Mass Index

NDNS – National Diet and Nutrition Survey

RNI – Reference Nutrient Intake

EAR – Estimated Average Requirement

Abstract

Background/objectives: Simple screening tools to measure nutritional adequacy in a public health context in developed countries are currently lacking. We explore the relationship between food variety and nutrient intake of London school children using a simple tool with potential use for screening for inadequate diets.

Subjects/methods: A cross-sectional survey was carried out in 2010. The survey included 2579 children aged 7-10 years in 52 primary schools in East London in the UK. The analysis included 2392 children (93% of the original sample). Food variety was assessed as the total number of listed foods recorded over 24 hours using the validated Child and Diet Assessment Tool (CADET) comprising 115 listed foods divided into 16 food categories. Dietary quality was determined by the proportion of children meeting recommended intakes of individual micronutrients, namely; calcium, iron, zinc, folate, vitamin A and vitamin C.

Results: The mean number of CADET listed foods consumed daily by children was 17.1 (95%CI 16.8, 17.5). Children who consumed fewer than 11 foods on the collection day had particularly low nutrient intakes. Children consuming 3 different vegetables and 2 different fruits on average consumed 19-20 listed foods. It was estimated between 4 and 20% of children did not meet the recommended levels for individual micronutrients during the period of data collection.

Conclusions: A simple method using food counts to assess daily food variety may help public health nutritionists identify groups of children at risk of inadequate diets.

Introduction

A high quality diet recommended by the World Health Organisation (WHO) contains more fruits and vegetables and lower trans fats and free sugars, and is associated with reduced risk of common non-communicable diseases such as type 2 diabetes[1, 2]. Developing good dietary habits in childhood is important since these can track into adulthood[3]. However, many children and adolescents in developed countries have poor quality diets and high levels of obesity[4]; and children from low income households tend to have worse diets[5] with lower intakes of many vitamins and minerals[6], higher likelihood of missing meals[7] and higher rates of obesity[8-10].

Quality assessments of the whole diet can be difficult, particularly in children. There is no universally agreed definition of diet quality, although the term is often used in relation to meeting dietary recommendations of optimum levels of foods and/or nutrients such as the Healthy Eating Index (HEI)[11]. Nutrient scoring involves analysis using dietary software[12-15] but simpler methods that provide a score without the need for software are potentially more useful as quick screening tools. A simple tick list that collects food variety data [14, 16-20] may be an easier and less burdensome method. Very low burden methods or screening tools that simply count food variety in children which could be used to indicate dietary quality in a public health or clinical context are currently lacking. Existing research on UK and US adults have reported the importance of food variety on dietary quality, including nutrient adequacy[21-23], but there is little research on children.

Studies have highlighted the importance of diets rich in calcium,[24] iron,[25] folic acid[26], zinc[26] and vitamin A[26] and the roles these nutrients play in cell division, growth, cognitive development and long term health[27-29]. With the addition of vitamin C, these micronutrients, are also included in the nutrient standards for school meals in England[30]. We therefore

suggest a micronutrient approach to assess dietary quality in children. As a measure of adequacy, we have used Estimated Average Requirements (EAR), the level needed to meet the needs of half the population[31].

Our aims were to explore how a simple count of food variety, with an emphasis on fruit and vegetables, is related to nutrient intake in primary school children, and whether such a tool has potential use for low burden screening for inadequate diets in groups of children. We focussed on intakes of micronutrients previously associated with good health by determining the proportion of children in our study consuming lower than the EAR for calcium, folic acid, iron, zinc, vitamin C and vitamin A based on foods consumed in a single day and standard portion sizes.

Methods

Secondary analysis of cross-sectional data was undertaken using baseline dietary measurements collected from 2579 children (aged 7-10 years) who participated in a randomised controlled trial (RCT) to evaluate the Royal Horticultural Society (RHS) School Gardening Programme (NIHR project number PHR Project 09/3001/19). Dietary data were collected between November 2010 and January 2011 from children attending 52 primary schools in eight deprived and ethnically diverse London boroughs. The trial was powered to see differences in fruit and vegetable consumption of 0.5 portions. Trial registration number ISRCTN11396528, details of this trial are described elsewhere[32, 33]. Ethical approval was obtained from Leeds Institute of Health Sciences and Leeds Institute of Genetics, Health and Therapeutic joint ethics committee (Reference number: HSLT/09/012 amendment 2). Written informed consent from schools and parents of children taking part was obtained.

Dietary intake was assessed prospectively over 24 hours using a modified version of the validated Child And Diet Evaluation Tool (CADET) diary which comprises a tick list of 115

food and drink items, divided into 16 food categories[34, 35] (see supplementary material for categories). The CADET does not require users to estimate portion size but uses age and gender specific food portion sizes based on 7 day weighed intakes collected for the National Diet and Nutrition Survey (NDNS) of young people[36] to calculate food and nutrient intake. The CADET diary was split into two: a school diary to record all food consumed at school, and a home diary to record all food consumed at home. Both diaries included the same food items, with different meal/snack time options. Trained fieldworkers filled in the CADET diary during the school day (morning break, lunch, afternoon break), and parents completed the diary for evening and morning food consumption (after school/before tea, evening meal/tea, after tea/during night, and breakfast/before school) [35, 37] Each listed food consumed, was ticked under the appropriate meal time. Fruit salad, for example, is a separate listed food and would add a count of one to the food variety score. A DVD explaining how to complete the CADET diary was sent home for parents/carers and children to watch https://www.youtube.com/watch?v=AIbzqaJiHq0. If sections of the diaries were not completed or children forgot to return the home part of the CADET, a fieldworker asked the children to report this information during an interview on the following day to minimise missing data and reduce bias. Different fruits, vegetables and meats are counted as separate foods, whereas carbonated drinks which have a similar nutrient profile contribute one food. Children's intake was analysed in relation to the UK EAR intake of micronutrients for 7-10 year old children[31], and to updated EARs for energy, total fat and total carbohydrates for 8 year old boys and girls[38], the mean age of the children. EARs for maximum recommendations of total fat and carbohydrates were calculated based on 35% and 50% respectively of the energy EARs for 8 year olds, and energy was assessed in relation to +/-20% of the EARs for the average 8 year old.

Children were excluded if they did not complete a food diary for the whole day, that is, they had a missing home or school section, or they had extremely high energy intakes of more than 5410Kcal or high fruit and vegetable intakes of more than 999g. The mean number of CADET listed foods consumed for children meeting, and not meeting, the recommended intakes of a number of micronutrients were calculated. Similarly the mean number of listed foods consumed by children missing meals, and those not missing meals was calculated. The mean number of listed foods consumed by quintile of energy intake was also produced. A food variety score was generated ,using the total number of different listed foods consumed. Children were then split into one of seven 'food variety' groups according to the number of listed foods consumed in the 24 hour period: 4-10, 11-12, 13-14, 15-16, 17-18, 19-20, 21+ foods (no children consumed less than four food types). These groupings allowed for a roughly equal distribution of children. Graphs were produced indicating the percentage of children meeting recommended amounts for the six micronutrients and energy for each of the seven food variety groups. The graphs were repeated for those who ate sweet and/or savoury snacks and for those who did not; to check whether excluding energy dense foods had an effect on the results (see supplementary materials). Additionally, the mean number of listed foods consumed in each of the 16 food categories (e.g. drinks, fruit as shown in table 3), was calculated for different food variety groups to determine recommendations for an optimal diet in terms of dietary quality. To determine whether social deprivation was associated with not meeting the EARs, the mean Index of Multiple Deprivation (IMD) for those meeting the EAR for each nutrient was compared to the mean for those not meeting the EARs using two-sided t-tests. The post code for a child's home was used to determine IMD (which ranged from 2 to 70 in this dataset), if this was not available the post code for the school was used. Analyses were performed using Stata version 13; the confidence intervals or standard errors of means and proportions took into account the clustering of children within schools. P values of lower than 0.05 were taken as significant.

Results

Out of 2579 children recruited into the trial at baseline who provided consent, 2461 children returned completed food diaries. After excluding 69 children who did not complete one or both of the sections (home and school) of their food diary; thirty nine children were excluded due to very high energy intakes and 30 children were excluded due to very high fruit and vegetable intakes. The final sample size was 2392, 93% of the original sample. The mean age of the children was 8.3 years (SD 0.7) (1188 girls and 1204 boys). Twenty-eight percent of the children received free school meals and 33% of the sample ate a packed lunch. English was spoken as an additional language by 47% of the sample. Education was reported by 60% of the families, and of those, 39% had a member of the family educated to degree level or higher. Postcode information was provided by 878 families (37%) used to determine IMD score (Table 1); with school postcode used for the remaining pupils.

Nutrient intake adequacy

The majority of children met the recommended intakes of the important micronutrients on the single collection day (see table 1). However, 18.0% did not meet the EAR for zinc, 18.4% for vitamin A, 11.0% for iron, 9.5% for calcium, 7.1% for folic acid, and 3.8% did not meet the micronutrient intake for vitamin C. For energy, 40.3% of boys and 28.6% of girls had intakes below the gender specific EARs, boys being 68% more likely have intakes below their EAR for energy than girls. Boys were 31% to 51% less likely to meet the EARs for the specified micronutrients than girls, and differences were statistically significant for energy, zinc, folate, iron, vitamin A, but not calcium or vitamin C. There were no associations between higher IMD score, i.e. higher deprivation, and not meeting EARs, except for folic acid where children who did not meet recommendations on the day were more likely to be from more deprived areas (IMD score (95%CI= 36.3 (34.3, 38.3) compared to 32.8 (32.2, 33.4) (p=0.002)).

Food Variety

In the total sample, the mean number of different CADET listed foods consumed over the day was 17.1 (95% CI 16.8, 17.5) out of 115 listed in the diary. The increase in mean nutrient intake by the increase in numbers of listed foods (food variety) consumed per day is detailed in table 2. Figure 1 shows how the percentage of children meeting EARs for individual micronutrients varies food variety group. The proportion of children meeting individual micronutrient requirements is higher as the number of listed foods consumed increases; once 19-20 food items/day are consumed 90% or more children met the EARs for all the micronutrients of interest. For the 4-10 food items/day group the percentage of children meeting nutrient requirements is particularly low. In this sample, 136 children (5.7%) reported that they consumed 10 foods or fewer on the day of recording. In relation to energy EARs, children were more likely to exceed + 20% energy EARs if they consumed over 14 different foods; similar distributions were observed for those who consumed no snacks and confectionery (N=130) (see supplementary data Figure 1), and for those who did consume snacks and confectionery (N=2082) (see supplementary data Figure 2).

As food variety increased, the number of listed foods consumed in all 16 categories increased (see table 3). Higher food variety occurs as children eat more of all types of foods, but particularly for vegetables and fruit. Children who consumed a total of 19-20 listed foods, on average typically consumed three different types of vegetables and two different types of fruit. On average drinks, pizza, pasta, rice, snacks and breakfast cereal provided the most variety for children who only consumed a total of 4-10 listed foods.

Missing meals had an impact on food variety. Out of 2392 children, 3.5 % (84) missed any meal, 2.0% (49) missed breakfast, 0.3% (7) missed lunch, 1.6% (37) missed the evening meal and 0.4% (9) missed more than one meal. The mean number of listed foods consumed by

children who missed a meal was 12.4 (95%CI 11.4, 13.5) compared with 17.3 (95%CI 16.9, 17.7) for those not missing a meal. Food variety was also lower for those children consuming diets lower in energy. The mean number of listed foods consumed by quintile of energy intake was 12.5 (95%CI 12.1, 12.9) in the lowest quintile, 14.8 (95%CI 14.5, 15.1) for Q2, 16.7 (95%CI 16.3, 17.1) for Q3, 18.5 (95%CI 18.2, 18.9) for Q4 and 23.1 (95%CI 22.5, 23.7) for the highest quintile.

Discussion

We aimed to explore the relationship between food variety and nutrient intake of London school children using a low burden simple tool with potential use for screening for inadequate diets. Food variety was determined using a food-based count from a food tick list tool (CADET), requiring no scoring from nutrient estimates. The analyses did not classify individual children in the study, but indicated group mean nutrient intakes. On average in this single day assessment, about 19 or more different listed foods or drinks (out of a possible 115 listed on the CADET tool) needed to be consumed for an optimal diet in terms of selected micronutrients and our results indicate this would also typically include three different types of vegetables and two types of fruit. As food variety increased, mean energy intake also increased. If 19 or more food items were consumed, 90% of children had energy intakes above the recommended levels which has implications for weight gain. Lower food variety on a single day was associated with risk of not meeting recommended amounts of nutrients, particularly zinc and vitamin A. If the number of food items was below ten foods, children were at extremely high risk of not meeting any of the studied micronutrient requirements on the day. Children who missed a meal or had low energy intakes had less variety in their diets and consequently lower quality diets in terms of nutrients.

There is little research on food variety in developed countries, other than in adults[21-23]. In UK adults, higher food variety scores were associated with both increased nutrient adequacy and

reduced all-cause mortality; this used a simple count of foods consumed at least once a week from a 127-item FFQ with a large proportion of listed fruit and vegetables[22 23]. In the British NDNS rolling programme[4], micronutrient deficiencies were highlighted in some children and adolescents particularly vitamin A (6% children, 13% adolescents) and iron intakes (1% children, 26% adolescents). Children at high risk of poor quality diets may be going unnoticed because they consume sufficient or too much energy but insufficient levels of micronutrients; many measures to assess dietary adequacy in children are based on measures of body fatness[39]. A simple food variety measure may be needed to identify groups at risk of poor nutrient intake that focuses on meat, fruits, vegetables, pulses and wholegrain; the main food sources of important micro-nutrients. There is evidence that children from the most socially deprived areas are more likely to have poor quality diets eating high energy dense food, and to be overweight or obese[40, 41]. This may be due to food insecurity or food insufficiency where there is a lack of access to sufficient quantity of affordable nutritious food for economic or other reasons respectively[42-44]. Surprisingly, we found little evidence of associations between IMD and meeting nutrient intake recommendations, except for folic acid. However, the proportion of children having a free school meal (28%) in this study was much higher than the average for England (17%) which may have attenuated any existing association with deprivation.

Traditionally, screening tools for food security or food insufficiency do not consider food and associated nutrient intakes[18, 35,45], although missing meals is usually incorporated which is an important risk factor for poor quality diet[43, 46]. Results from the National Health and Nutrition Examination Survey (NHANES) report that around 8% of American children are food insufficient[47] with low serum micronutrient levels [46]. This is similar to the 6% of children we identified as being at particularly high risk of an inadequate diet due to consumption of ten

foods or fewer per day; however this percentage may reduce if more days of intake were collected as food intake usually varies by day, resulting in regression to the mean.

There were a number of strengths of this study. This is the first to explore methods of assessment to predict the risk of an inadequate diet in children in developed countries based solely on a simple count of food variety. The CADET diary was designed to focus on fruits and vegetables so is weighted towards healthy foods in terms of variety score. This means higher scores are more likely to be achieved through consumption of a variety of fruit and vegetables (13 and 22 food items respectively were listed on CADET for these - see supplementary materials) than through consumption of sugar sweetened drinks, puddings, confectionery and snacks which accounted for a smaller number of listed foods (1, 6, 2, 8 respectively on CADET). The similar results obtained when sweet and savoury snacks were excluded supports this interpretation. This increases the likelihood that a high score was based on a higher number of healthy foods. This emphasis on fruit and vegetables is similar to the FFQ used to score food variety in UK adults which was associated with both nutrient adequacy and reduced all-cause mortality[22]. In our study, a large sample of detailed dietary data was obtained using a validated tool collected by trained fieldworkers in children from diverse backgrounds and analysis took into account clustering within schools. Dietary intake was similar to typical diets of children of this age group in many high income countries and, based on eligibility for free school meals, was representative of the region.

There were notable limitations. The sample of children was not necessarily representative of other regions of the UK. There is no universally agreed definition of a low quality diet although our definition based on important micro-nutrients is one possible approach[11]. Our data only covers one 24 hour period, and is not representative of individual usual intake. The average number of foods and nutrients consumed over a week would be closer to the mean and fewer children would be in the lowest food variety band. Intake of foods was estimated

using an average portion size from weighed records in the UK NDNS according to age and gender[34] rather than asking children to state their portion size. However, children who consume a very low variety of foods may consume larger portion sizes than average for the foods they do consume, and vice versa for those consuming a high variety of food. Therefore, it is possible we overestimated intake for some children, particularly those having the most varied diets and underestimated intake of those with low food variety. It is possible that the number of children who actually missed a meal is less than reported if a parent forgot to fill in part of the diary although steps were taken to minimise missing data. Additionally, socially desirable answers may have been given by parents in the home diary; they may have been more willing to report healthy food than unhealthy foods, with snack foods and beverages more likely to be under-reported. Lastly, we did not collect any information on body mass index (BMI) or measures of food insecurity which meant we could not identify children who were underweight. To avoid the food variety score just reflecting unhealthy foods, energy dense foods such as savoury and sweet snacks could be excluded, although they are currently low in number and excluding them from the count had little effect. In addition, more work is needed to determine how the number of CADET foods consumed changes if intakes are assessed over a period of days, which would be necessary to assess diets of individuals,. This should include validation against weighed dietary records and health outcomes[48].

In summary, a simple count of food variety may be useful to identify groups of children consuming less than optimal diets. A simple tick list questionnaire could be included, as part of a regular health check at school or in the community. This would avoid the need for specialised nutritional analysis software and interpretation. However, more research into the sensitivity and specificity of this suggested approach is warranted, particularly relating to the optimum number of dietary days needed and the need for specific portion sizes.

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Author contributions

CELE designed the research protocol and the original statistical analysis plan, secured the additional funding for the additional analysis, wrote the first manuscript and contributed to all versions of the manuscript. JH designed and carried out the analysis, wrote a report and contributed to all versions of the manuscript. JEC contributed to all versions of the manuscript. NH managed the database, made available all data in the analysis and contributed to the final version of the manuscript. MSC managed the data collection of the NIHR project and contributed to the final version of the manuscript.

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Figure Legends

Figure 1: Percentage of London school children aged 7-10 years meeting EAR nutrient requirements by number of CADET listed foods consumed in a day