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Abstract

Objective: The aim of this study is to evaluate the association between the frequency of consuming takeaway meals and meals-out and diet quality of UK adolescents.

Design: The Diet Quality Index for Adolescents (DQI-A) tool was used to assess diet quality where adolescent's food intake was based on 4-day diary records obtained from the UK cross-sectional National Diet and Nutrition Survey (NDNS) rolling programme Years 1-6. Models included confounders.

Setting: The DQI-A relies on three components, specifically diet quality, diversity and equilibrium which reflect the degree of adherence of an adolescent diet with Food Based Dietary Guidelines (FBDG).

Subjects: 2045 British adolescents aged 11-18 years.

Results: The mean diet quality score for all adolescents was 20.4% (overall DQI-A score range is -33 – 100 %). After adjusting for age, gender and equivalised household income, the DQI-A% score was higher for low and moderate takeaway consumers by 7.4% (95% CI 5.5, 9.2; $p < 0.01$) and 3.5% (95% CI 1.9, 5.1; $p < 0.01$) respectively compared to frequent consumers. Significant differences were also observed between low, moderate and frequent takeaway consumers among all DQI-A components and sub-components ($p < 0.05$), except for the diet adequacy sub-component (DAx). The results for frequent consumption of meals-out were similar but attenuated and not statistically significant for individual components before or after adjusting for confounders.

Conclusions: Frequent consumption of takeaway meals may have a negative impact on diet quality of adolescents and therefore policies to reduce the intake of takeaways should be considered in this age group.

Keywords Diet quality index, Adolescents, Takeaways, Meals-out

Introduction

The significant global rise in diet-related non-communicable diseases indicates that there are serious nutritional issues in both developed and developing countries[1]. The World Health Organisation (WHO) 2015, announced that cardiovascular diseases were responsible for the largest number of deaths[2]. In 2013, WHO declared that many of the diseases that exist are not only as a result of increasing rates of obesity and overweight among children, but also because of the unhealthy diet of children[3]. Poor diet, particularly due to intake of foods high in sugar and fat, is found to be one of the major threats to health and wellbeing[4]. The many different causes of childhood and adulthood obesity such as socioeconomic inequalities also include factors related to deprivation, education level and ethnicity. In the UK, observational studies report that lower socioeconomic groups consume less oily fish, fruit and vegetables and more red and processed meat and foods and drinks high in free sugars compared with higher socioeconomic groups[5]. In addition, the food environment also plays a crucial role on individual behaviours and food choices. For example, availability, accessibility, portion size and cost of different food types both at home and in surrounding food outlets are influential[6].

The main driver of overweight and obesity is believed to be the imbalance between energy intake and energy expenditure mainly due to the overconsumption of energy dense foods that are known to be high in fat and sugars as well as an increase in a sedentary lifestyle[7]. Overconsumption of energy dense foods derived from fast and convenience food outlets are believed to be an important contributor to the increased risk of obesity and type 2 diabetes among young generations[8, 9]. Two longitudinal prospective studies including young adults aged 18-30 years, with three to 15 years follow up, found that increased frequency of fast food restaurant visits[10] and consumption of fast food[11] can lead to increased body weight (baseline compared to follow up). In fact, higher fat consumption and total energy intakes are linked with takeaway and fast food consumption which offer a variety of ready-to-eat meals and energy dense foods[12]. Consumption of fast food remains positively and significantly associated with total energy intake and total intake of fat, saturated fat, carbohydrates, sugar, and sugar-sweetened beverages[10]. Consumption of takeaway meals and food purchased from outside the home (rather than food prepared at home) is found to be negatively associated with diet quality[11, 13]. In England, school children were observed to purchase foods from surrounding food outlets not only during lunch break but also during the journey going to and from school. Young people are specifically targeted for price promotion and many of those food outlets provide discounts on items such as sugar-sweetened drinks, hot food takeaways

and confectionary[14]. A recent cross-sectional study based in 3 cities in England (London, Birmingham and Leicester) found that 28% of children aged 9-11 years from 85 primary schools consumed takeaway meals once or more than once per week. LDL cholesterol, fat mass index and total cholesterol were all observed to be higher among students who consumed takeaway meals (equal to or more than once per week) compared to those who never or hardly consumed takeaway meals[15].

Previous research has assessed individual macro and/or micro nutrients, however the need for higher quality data to strengthen the evidence for overall diet is required. A simple, easy-to-interpret tool to indicate the quality of a diet without requiring intensive analysis of foods to nutrients in this age group has resulted in the development of the Diet Quality Index for Adolescents (DQI-A)[16, 17]. The DQI-A is based on the intake of food groups without including the intake of nutrients and it was adapted from a validated index called the Diet Quality Index for Preschool Children. The validated DQI for pre-schoolers was derived from the original DQI. The DQI-A was mainly developed to assess the degree of adherence of an adolescent diet with the Food-based Dietary Guidelines (FBDGs)[18]. The FBDGs, also known as dietary guidelines, are used to provide sufficient information for different governmental sectors to implement interventions toward healthy eating and lifestyles. Such interventions can focus on food and nutrition, polices regarding health and agriculture and educational programmes. Therefore, the primary role of FBDGs is to provide advice to the general public, thereby enabling individuals to meet their daily dietary requirements of both nutrients and food groups; this will help in preventing chronic diseases and promoting healthy lifestyles[19]. The aim of this study is to evaluate the association between the frequency of consuming takeaway meals and meals-out and diet quality of UK adolescents aged 11-18 years.

Methods

The data used for this study was from the National Diet and Nutrition Survey, an annual rolling programme aiming to assess nutritional intake and status of people living in private households in the UK aged 1.5 years and above. In each year of the survey, a sample of 500 adults (aged 19 years and over) and 500 children (aged 1.5 -18 years) were randomly recruited based on postcode. Randomly selected addresses were posted information leaflets describing the purpose of the NDNS survey and a consent form. These were followed up by a face to face visit by the interviewers. For children aged under 16 years, consent was sought from both the child and their parents for the interview, blood and urine sampling. For adults aged 16 years and above, consent was obtained for the blood and urine sampling. Ethical approval for this

study was obtained from the Oxfordshire A Research Ethics Committee[20]. In this study, all participants aged 11-18 years from the NDNS datasets 2008 to 2014 were involved (Years 1-6).

Variable of interests

Takeaway meals and meals-out

The interviewers asked the participants two questions on fast food to collect data relating to their eating habits. In both questions, the interviewers provide further clarifications for the terms meals-out and takeaway meals at home. These questions are: '' On average, how often do you/does child eat meals out in a restaurant or cafe?", where the meals mean more than a beverage or bag of chips; and "On average, how often do you/does child eat take-away meals at home?", where the meals mean more than a beverage or bag of chips including pizza, fish and chips, burgers etc. Using frequency of consuming takeaway meals at home and consuming meals outside the home, respondents were categorised as low consumers (including rarely/never), moderate consumers (including once per month) and frequent consumers (including 1–2 times per week, 3–4 times per week and 5 or more times per week). Participants with 'do not know' answers were excluded from the analysis. This method of categorisation has been used previously, as it has been reported that the risk of developing health related diseases is linked with consuming fast food more than once per week[21, 22].

Food intake

The intake of food was obtained from the 4-day diary records. The diet quality score was calculated for each day and the mean value of the 4 days was then calculated and used to assess the diet quality index of the adolescent participants. Some food items were excluded from the analysis, including commercial toddler drinks and foods. Those food items were excluded because this project only involved adolescents aged 11–18 years and toddlers' food and drink are not typically consumed by older children.

DQI-A (Diet Quality Index for Adolescents)

The latest version of the FBDG in the United Kingdom is the Eatwell Guide, which was published in 2016 by Public Health England (PHE) and consists of seven main food groups as follows: (1) potatoes, bread, rice, pasta and other starchy carbohydrates; (2) dairy and alternatives; (3) beans, pulses, fish, eggs, meat and other proteins; (4) fruit and vegetables; (5) oil and spreads; (6) water; and (7) confectionary and high fat and sugar snacks[19, 23]. The Flemish FBDG, which was used to validate the DQI-A, include mostly the same recommended food groups mentioned in the Eatwell Guide. Like FBDG, the DQI-A relies on three main

components, namely the quality, diversity and equilibrium of the diet compared to the governmental dietary guidelines. Each component has its own definition and technique for the scoring criteria[17].

Diet quality component (DQc)

This component assesses diet based on the quality of the obtained food within the nine recommended food groups, namely (1) water; (2) bread and cereal; (3) potatoes and grains; (4) vegetable; (5) fruits; (6) milk products; (7) cheese; (8) meat, fish and substitutes; (9) fat and oils. To calculate the score, the amount of consumed food (m) from each food group is multiplied by a weighting factor. The weighting factor is divided into three groups, namely the preference, intermediate and low-nutrient/energy-dense groups. Each weighting factor has an associated digit, as follows: '+1' for the preference group, including cereal/brown bread, fish and fresh fruit; '0' for the intermediate group, including white bread and minced meat; and '–1' for the low-nutrient/energy-dense group, including soft drinks, sweet snacks and chicken nuggets . First, the diet quality was calculated for each of the nine food groups and then, the final score of this component was calculated using the following equation: $\sum$ (DQ) / $\sum$m x 100%. More details and examples about the classification of food items and the scoring criteria of weighting factors, can be found elsewhere[17].

Diet Diversity component (DDc)

The diet diversity component (DDc) assesses the degree of variation in an adolescent's diet, where the scoring range is from zero to nine points. Consuming at least one serving from each of the nine recommended food groups adds one point to the total score. For example, if an individual's mean consumption for the fruit group is more than 80 g, this individual gains a score of one; otherwise, the score will be zero. The final score for this component can be calculated using the equation $\sum$ (DD) / 9 × 100% (sum of DD points for all nine food groups for each individual). In terms of serving size, as the Eatwell Guide does not provide information regarding portion and/or serving size for all the recommended food groups, the portion size recommended by the British Dietetic Association (BDA) was used as follows: (1) water, 200 ml; (2) bread and cereal, 35 g; (3) potatoes and grains, 175 g; (4) vegetables, 80 g; (5) fruits, 80 g; (6) milk products, 200 ml; (7) cheese, 30 g (8) meat, fish and substitutes, 100 g; and (9) fat and oils, 4 g. To gain a better and more accurate measurement of recommended portion sizes of these food groups among children and adolescents, other reference source was used, such as those of the Food Standard Agency, especially for starchy food groups[24, 25].

Diet Equilibrium component (DEc)

The diet equilibrium component (DEc) consists of two subcomponents, namely the adequacy component (diet adequacy, DAx) and the excess component (diet excess, DEx). These two subcomponents express the degree of adherence of an adolescent diet to the minimum and maximum intakes of each of the nine recommended food groups. The adequacy component represents the percentage of the minimum recommended intake of each of the nine food groups, converted to '1', whereas the excess component represents the percentage of the intake exceeding the upper limit of the recommendation (11 food groups, nine recommended and two non-recommended), converted to '1' if larger than 1 and converted to '0' if below 0. Then, the dietary equilibrium is calculated by subtracting DEx from DAx (i.e. DE = DAx – DEx). Finally, the total diet equilibrium score can be calculated by dividing the sum of diet equilibrium scores by 11 and multiplying by 100% ($\sum$ (DE) / 11 ×100%). The recommended daily intake of all food groups is based on the Flemish FBDG, where the minimum and maximum intakes of each of food group are provided. More details on how to calculate each of these subcomponents can be found in published documents[17].

Total DQI-A score

All three main components – diet quality, diet diversity and diet equilibrium – are presented in percentages. The percentage ranges for both DDc and DEc are 0–100%, whereas the DQc percentage range is –100 to 100%. Therefore, the mean percentage of the three main components, result in a DQI-A score ranging from –33 to 100%. A higher DQI-A percentage score reflects a better quality of diet.

Statistical analysis

All statistical analyses were carried out using Stata statistical software, version 15.0 (College Station, TX: StataCorp LLC). Different NDNS datasets were merged before analysis. The dietary dataset was merged with either household or individual using ISERIAL as the unique identifier for individuals. In addition, the datasets for Years 1–4 and 5–6 were combined, as each of these was provided individually by NDNS. Applying weight analyses to a dataset is required to adjust for non-responses, for example, in the NDNS for individual and/or household datasets. The weighting variable provided in the NDNS guideline report was used, allowing generation of an equal distribution of the selected population across the four parts of the United Kingdom; thus, the results obtained from the year 1 to year 6 surveys are able to be used together.

In addition, the distribution of variables were checked before any statistical test could take place, including comparison of means of the t-test, analysis of variance (ANOVA) comparison

test and multiple or linear regression analysis. Simple summary description was conducted to provide general information related to this study such as response rate, the proportion of participating males and females, ethnicity and survey year distribution. Mean scores and confidence intervals of DQI-A and its components were assessed. A comparison test was also carried out to examine the differences between dietary quality score and its components between the 4 diary day records.

Linear regression was then applied, taking into consideration the clustering effect of the individuals, by their unique ID number to estimate the association of the overall diet quality score or its components (outcome variables) with takeaway meals or meals consumed out of the home (exposure variables). The results for the linear regression were presented as unadjusted figures applied alone or as adjusted figures after controlling for age, sex and equivalised household income. Equivalised household income is standard methodology required to adjust the differences in financial resources for differences in type of households such as size[26]. P-values of less than 0.05 were considered as statistically significant for all tests and 95% confidence intervals were presented with results.

Results

Background description

In total, 2045 adolescents were recruited into the NDNS and completed a minimum of 3-day diary records; 98% of these participants had 4-day diary records. The proportion of females was slightly higher than that of males, at 51.5% (n = 1033) and 49.5% (n = 1012) respectively; the mean age of both genders was 14.6 years. In terms of ethnicity, 90.8% of adolescents were reported to be white, while 9.2% were from non-white ethnic backgrounds. The weight measurement (kg) was only valid for 1981 participants and females had a significantly lower weight than males, by 2.3 kg (95% confidence interval [CI] –3.7, –1.0; $p < 0.01$). Males had significantly higher food energy intake than females, with a mean intake of 8138.9 kJ/day (95% CI 8005.4, 8272.5; $p < 0.01$) (Table 1). The response rate for information on physical activity level was less than 50%, representing all age groups from both genders (data not shown).

The overall DQI-A% score was broadly similar across the days with no statistical significant differences between the days (Table 2). However there were small but significant differences observed among the percentage scores for the different components and subcomponents with significant differences in scores observed between the days for DDc, Diet diversity component, DEc, Diet equilibrium component; DAx, Diet adequacy sub-component and DEx, Diet excess sub-component, except DQc, Diet quality component. Furthermore, participants who

completed 4-day diary records had higher overall DQI-A% score by 4.6% (95% CI 0.9, 0.8; p =0.014) than participants who had 3-day diary records. Evaluation of the mean score of overall diet quality index and its components and sub-components among all three takeaway and meals-out consumer groups can be seen in Table 3 and 4. The UK adolescents had a mean diet quality score of 20.4% out of 100% (ranging from –24.2% to 67.2%).

Takeaway and meals-out consumption

The frequent consumption of takeaways (1-2 times/week or more) was reported by 29.8% (n=589) of participants, whereas 24.3% (n=496) of them reported to be frequent meals-out consumers. The majority of the participants were moderate consumers (once per month) of takeaways (44.3%) and meals-out (46.8%). Those who reported to rarely or never consume takeaway meals or meals-out represented 26.9% and 29.0 % of the total number of participants, respectively. The percentages of adolescents reporting frequently consuming takeaways were 37% and 28% for those that completed 3-day and 4-day diaries respectively. Similarly, the percentages of adolescents reporting frequently consuming meals-out were 31% and 24% for those that completed 3-day and 4-day diaries respectively. The proportion of participants who consumed takeaway meals 1–2 times per week or more was found to be higher among participants with the lowest equivalised household income compared to those with highest income. However, this was not true of the consumption of meals outside the home. As can be seen in Figure 1, 13% (n = 68) of the frequent meals-out consumers were from lowest income households, whereas 17% (n =85) of them came from the highest income households.

In addition, it was observed that the mean intake of vegetables was 134g among low takeaway consumers compared to 102g among frequent takeaway consumers. This difference was greatly attenuated among meals-out consumers where the mean intake of vegetables was 117 and 112g among frequent and low consumers, respectively. In this study, overall DQI-A score and its components and subcomponents were recalculated after increasing the intake of vegetables by one portion (80g) to demonstrate the effect of this typical change in diet on different components. It was observed that components scores for DQc, DDc, DEc and DAx increased on average by 2.9%, 3.9%, 1.8% and 2.1 %, respectively. A mean increase of 2.9% on the overall DQI-A score was seen (data not shown).

Associations between diet quality and takeaway consumption

The results from the regression analysis indicate there is an association between the frequency of takeaway consumption and diet quality of UK adolescents. Significant differences were observed between low, moderate and frequent (the reference group) takeaway consumers in

their DQI-A scores (Table 5). Low and moderate takeaway consumers had a higher overall DQI-A% score by 7.4% (95% CI 5.6, 9.2; $p < 0.01$) and 3.7% (95% CI 2.2, 5.2; $p < 0.01$) than frequent consumers, respectively. The results remained essentially unaltered after adjusting for age, gender and equivalised household income and the overall DQI-A% score remained higher for low and moderate consumers compared to frequent takeaway consumers (Table 5). In addition, significant differences were observed between low, moderate and frequent takeaway consumers among the majority of the DQI-A components and subcomponents (Table 5). For instance, low and moderate takeaway consumers had significantly higher DQc% scores than frequent takeaway consumers by 14.2% (95% CI 10.5, 17.9; $p < 0.01$) and 6.7% (95% CI 3.6, 9.9; $p < 0.01$) respectively, before adjusting for confounders. This difference remained significant after adjusting for age, gender, equivalised household income. As indicated, not all diet quality components and sub-components were significantly affected by the frequency of takeaway consumption before and after adjusting for confounders (Table 5).

Associations between diet quality and meals-out consumption

The results for frequent consumption of meals-out were similar but attenuated and not statistically significant for individual components, including DDc and DAx before adjusting for confounders (Table 6). As was found with frequent takeaway consumers, the overall diet quality index percentage score (DQI-A) was significantly higher among low and moderate consumers compared to frequent consumers of meals-out (the reference group), by 2.8% (95% CI 1.0, 4.6; $p < 0.01$) and 3.4% (95% CI 1.7, 5.0; $p < 0.01$), respectively. Moreover, after adjusting for confounders including age, gender and equivalised household income, statistical significant differences among overall DQI-A% score were observed between low, moderate and frequent consumption of meals outside of the home (Table 6). Although there were significant differences observed between low, moderate and frequent meals-out consumers among some of the diet quality components, after adjusting for confounders those differences were observed to be bigger among some diet quality components (Table 6).

Discussion

This is the first study to assess the relationships between the consumption of takeaway foods and meals-out of the house and diet quality in adolescents using an overall diet quality index and representative national data from the UK. The DQI-A was used to assess the adherence of British adolescents to dietary recommendations and healthy eating patterns. The results from this cross-sectional study suggest that frequent consumption of takeaways in particular is

negatively associated with overall diet quality and its components. A weaker but nevertheless significant association was seen with meals-out consumption.

The mean diet quality score was 20.4% for all adolescents, which is lower than the score obtained from a previous study using the NDNS (data from years 1–4, but excluding years 5–6) which reported a score of 31.1% overall and also differences in some sub-components[27]. This may be due to the slightly different methodology used for the categorisation and classification of main food groups and subgroups, including portion sizes, which influence each of the diet quality components and subcomponents. For example, a previous researcher excluded non-milk-based ice-cream and beverages dry weight items from the analysis[27]. In this study, both of these food items were categorised within the low-nutrient weighting factor group. Alternatively, it may reflect a further worsening of diet quality in British adolescents which are already worse than other European countries. In comparison to previous European surveys, the mean diet quality score of adolescents (DQI-A) from mainland Europe were considerably higher than they were for UK adolescents, with scores between 50 and 60%[17, 28].

The UK population enjoys consuming food that is already prepared and currently has the highest rate of ready meal consumption in Europe, double that of France and six times more than Spain[29]. This trend is not showing any sign of abating. There has been a dramatic increase of 43% in the number of takeaway and fast food outlets in the UK since 1990[30, 31]. Typically, out-of-home meals from restaurants, cafés, takeaways, fast food restaurants and sandwich shops are higher in saturated fat, sugar and total energy[32]. A cross-sectional study in England that included 332 secondary school students aged 13-17 years, showed that around 23% of the recommended energy intake of these students was obtained from foods purchased from fringe shops near schools. The nutritional quality of the purchased food items was found to comprise 38% saturated fat, 22% sugar and 15% non-milk extrinsic sugar[33]. Observational evidence from neighbouring Scotland carried out in five secondary schools showed that although the number of food outlets located within 10 minutes walks varies from one school to another, the majority of the students during lunch break purchased unhealthy convenience foods from local shops such as fish and chips, pizzerias, kebab shops, cafes and supermarkets[34]. In the US, a national representative survey that recruited children and adolescents aged 4-19 years stated that fast food consumers had a higher intake of total fat, saturated fat, total carbohydrate and sugar-sweetened beverages. Moreover, lower intakes of fluid milk, fruits and non-starchy vegetables were observed among fast food consumers[35]. The methodology used in this study

to calculate DQI-A score, means that foods high in fat, sugar and sweetened beverages are more likely to be classified within low-nutrient food items (non-recommended food products) that have a negative impact on not only overall DQI-A% score but also in its components scores. Conversely, food items such as liquid milk and fruit and vegetables enhance the overall DQI-A and its components scores.

The effects of frequent takeaway consumption on diet quality were larger than the effects of frequent meals-out consumption both before and after adjusting for confounders. Different studies have different definitions for the terms 'out of home eating'[36] and of fast food[37] which may result in comparisons of effects on diet quality being difficult. However, despite the difficulties with defining fast food, studies have consistently found that fast food is poor quality compared with other types of food purchased outside the home[38]. Results from a systematic review confirmed that the effect of eating out at a fast food outlet had a larger impact on energy intake among both US adolescents[12] and Irish children[39] compared with restaurant consumers. A cross-sectional analysis of data from 11 different European countries (including the UK) showed similar findings. Although the participants were adults aged 35 years and above, findings from Orfanos, Naska[40] study confirmed that location of eating out of home including work and restaurants affected not only energy intake but also other macro-nutrients such as carbohydrates, protein and fat. Two further cross-sectional studies that analysed data among adult participants from 10 European countries (including the UK) showed that eating location such as restaurants, home or work had an impact on energy intake and its contribution to the total daily energy intake[41, 42]. The place where the food was consumed out of home was clearly reported in these studies. This may have helped the researchers in exploring the source of this impact whereas the NDNS has incomplete information regarding the source of food consumed for either takeaways or meals-out. Most of the UK studies included in this systematic review[12] have not reported the sources where the food was consumed. In this study eating takeaway style food at home, such as fish and chips is likely to have come from a takeaway/fast food outlet (delivery services). Although both fast food outlets and restaurants are associated with higher energy intake and poor dietary patterns; portion sizes for foods such as soft drinks and french fries are larger in fast food outlets compared to food in restaurants and food prepared at home. Restaurants were found to have smaller portions of foods including burgers and desserts[42, 43]. This may explain the differences observed in this study between the effect of takeaway and meals-out food on overall diet quality and its components. Another UK study examined the effect of takeaway consumption and/or eating out on individual food groups

and/or nutrients[22], whereas assessing individual's dietary intake overall can be achieved through examining the dietary quality and variety of an individual daily diet[17, 44]. Overall diet quality may be a stronger predictor of health outcomes than individual food groups and nutrients. In addition, higher numbers of frequent takeaway consumers were from families with a low household income. A cross-sectional study showed that exposure to fast food seems to increase as the deprivation rate increases, and this indicates that people living in areas with higher social and economic deprivation are more likely to select cheaper sources of food[22]. The higher price of healthy foods is one of the greatest barriers effecting low income households' food choices[45]. Moreover, for people with lower household incomes who completed the Low Income Diet and Nutrition Survey, 2005[46], the most frequently reported barrier to healthy eating was the price of healthy foods.

Strengths and Limitations

There were notable strengths to this analysis. The data analysis presented in this study was generated in duplicate by two independent researchers; the NDNS is a national UK survey, and is considered to be high quality, representative and containing up to date information on eating behaviour in the UK population. However, it does have some limitations. In year 1, more weekend days were included in the study compared with other years of the survey which is considered to have an impact on estimates of nutrient and food intake. In the NDNS data, it was possible to identify the participants who did actually consume takeaway foods at home and outside the home during the 4 diary day records. However, foods such as burgers and kebabs, fried chicken, fried coated fish and others were labelled as prepared using home recipes, whereas foods such as pizza were not labelled as takeaway food or having been prepared at home, except for chips where participants indicated if they were purchased from a takeaway. This could have assisted in examining the effect of consuming takeaway foods on the DQI-A% score and its components for each of the 4 days by comparing days when takeaway food was consumed with days where no takeaway food had been consumed. Instead, the analysis of the DQI-A% score relied on the information on frequency of take-away food by participants, to categorise them as a frequent, moderate or low takeaway consumers. It is not possible to solely rely on the information collected during 4 days to assess intakes of takeaways as many people consume takeaway food less than once per every 4 days. Two percent of the participants only collected data for 3 days and these participants had lower mean diet quality and higher reported intakes of takeaway food. Participants who eat out more frequently may

be more likely to find completing a 4-day diary difficult and therefore may be more likely to drop out of the study, introducing bias.

In addition, eating out of home can be defined differently such as only food purchased and consumed outside of the home or also including food consumed out of the home but prepared at home. Additionally, there is no clear difference between restaurants and fast food outlets as some fast food outlets also have seating areas where customers can eat in[40]. Naska and Orfanos[47] confirmed the ambiguous area in the definition of eating out of home while at work which may lead to having inconsistent results. Only a brief general description of the difference was provided to participants in the NDNS leading to incomplete information being provided regarding takeaway meals at home such as pizza, fish and chips and burgers which could have been prepared at home or delivered from a takeaway outlet. Similarly with meals-out consumption, as the question focused on general examples such as restaurants or cafes, the importance of obtaining information regarding the source of food being purchased and consumed was ignored[48]. In addition, in the NDNS schools meals are excluded from being defined as a meal out.

The UK and other European countries, including Austria, Belgium, France, Italy and Germany, are following a similar approach to food group classification and have similar dietary recommendation, such as the Eatwell Guide, food pyramids and recommended portion sizes. However, further recommendations on the maximum and minimum intakes from each food group are more common in non-UK dietary guidelines (such as the Flemish dietary guidelines). The language barrier (lack of availability of European guidelines in English) was another obstacle to understanding the way in which other European countries implement their dietary recommendation and guidelines[49]. Although studies have been conducted using diet quality indices in the UK population[50, 51], the types of indices used and the ages of the targeted groups were different, which made the findings obtained from this study and the other UK based studies difficult to compare. Also, those challenges made the calculation of UK adolescents DQI-A and its components scores more difficult.

In addition, physical activity is an essential confounder to be included in the regression model, especially when weight (or BMI) is a health outcome of interest. However, due to the fact that less than 50% of the total participants provided a valid measurement regarding their physical activity level, the analysis was carried out without the inclusion of the physical activity variable in the model.

Policy and recommendations

Consumption of takeaway food is common in adolescents and therefore policies to reduce availability and accessibility of fast food are needed in this age group. This is particularly important as a recent Organisation for Economic Cooperation and Development (OECD) report noted that British adolescents have some of the worst diets in the world[52]. Reducing the density of fast food outlets near schools may be one method of achieving this which is recommended by Public Health England (PHE) although the impact on health has not been evaluated to date[53-55]. The food environment in schools and retail outlets such as supermarkets has improved in the last 10 years with new school meal standards and food reformulation to reduce trans fats, salt and sugar[56], however the fast food environment has worsened. Of particular concern is the higher density of fast food outlets in areas of social and economic deprivation and larger portion sizes of fast food[30, 53]. However, with no universally accepted portion sizes of healthy and unhealthy food it is difficult to make recommendations. This would help in designing more widely acceptable Food Based Dietary Guidelines (FBDGs) and more robust diet quality assessment methods[57].

Conclusion

In conclusion, UK adolescents have a poor-quality diet, particularly those that report frequent consumption of takeaway meals and to a lesser extent frequent consumption of meals-out. The negative effects of takeaway food on diet quality of UK adolescents may lead to long term health impacts on young people in the UK although we didn't include research to confirm this here. Further interventions such as actions to improve the fast food environment near schools are needed to improve dietary behaviour in young people.

Conflict of interest

The authors declare there are no conflicts of interest

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Table 1 Summary description of age, weight and food energy intake among adolescents (11–18 years) from the National Diet and Nutrition Survey (NDNS)

	Total sample			Males			Females		
	n = 2045			n = 1012			n = 1033		
	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Age (years)	14.6	14.5	14.7	14.5	14.3	14.6	14.7	14.5	14.8
Weight (kg)	59.1	58.4	59.7	60.2	59.2	61.3	57.9	57.0	58.8
Food energy (kJ)	7357.8	7266.9	7448.7	8138.9	8005.4	8272.5	6592.6	6488.1	6697.0

CI, Confidence Interval

Table 2 Mean scores of overall diet quality index and its components and sub-components across the 3/4 diary day records

	Total Number = 8145												Overall diet quality and it's components score (mean of all days recorded)
	Day Number												
	1st			2nd			3rd			4th			
	n = 2045			n = 2045			n = 2045			n = 2010			
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Average
DQI-A %	21.2	20.4	22.0	20.6	19.8	21.4	19.9	19.0	20.7	20.0	19.1	20.8	20.4
DQc %	-6.4	-8.1	-4.7	-6.0	-7.7	-4.3	-6.4	-8.2	-4.7	-6.3	-8.1	-4.5	-6.3
DDc %	46.3	45.6	47.1	44.7	43.9	45.5	43.5	42.7	44.3	43.8	43.0	44.6	44.6
DEc %	23.7	23.2	24.2	23.0	22.5	23.5	22.5	22.0	23.0	22.5	21.9	23.0	22.9
DAx %	55.5	54.9	56.1	53.8	53.2	54.4	52.8	52.2	53.4	52.2	51.5	52.8	53.6

DEx %	21.7	21.3	22.1	21.0	20.6	21.5	20.6	20.2	21.1	20.2	19.8	20.7	20.9

CI, Confidence Interval; DQI-A, Diet Quality Index for Adolescents; DQc, Diet quality component; DDc, Diet diversity component, DEc, Diet equilibrium component; DAx, Diet adequacy sub-component; DEx, Diet excess sub-component

Table 3 Summary description of diet quality components, age & energy among frequent, moderate and low takeaway adolescent's consumers

Dietary quality*	Total sample			Frequent takeaway consumers			Moderate takeaway consumers			Low takeaway consumers		
	n = 2045			n = 589			n = 906			n = 550		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
DQI-A Overall	20.4	19.7	21.0	16.8	15.6	17.9	20.5	19.5	21.4	24.2	22.9	25.5
Diet quality component (DQc)	-6.3	-7.7	-5.0	-13.2	-15.7	-10.6	-6.4	-8.3	-4.5	1.1	-1.6	3.8
Diet diversity component (DDc)	44.6	44.0	45.1	42.3	41.3	43.3	44.6	43.8	45.5	46.9	45.8	48.0
Diet equilibrium component (DEc)	22.9	22.6	23.3	21.1	20.5	21.8	23.1	22.6	23.6	24.5	23.8	25.3
Diet adequacy sub-component (DAx)	53.6	53.1	54.0	52.7	51.9	53.5	53.7	53.0	54.4	54.3	53.3	55.2
Diet excess sub-component (DEx)	20.9	20.6	21.2	22.0	21.4	22.6	20.8	20.4	21.3	19.9	19.3	20.5
Age (year)	14.6	14.5	14.7	14.6	14.4	14.8	14.5	14.3	14.6	14.6	14.4	14.8
Energy (Kcal)	1758.6	1736.8	1780.3	1809.2	1767.1	1851.4	1756.5	1725.4	1787.6	1707.7	1664.8	1750.7

CI, Confidence Interval; DQI-A, Diet Quality Index for Adolescents
*** Scores presented as %**

Table 4 Summary description of diet quality components, age & energy among frequent, moderate and low meals-out adolescent's consumers

Dietary quality*	Total sample			Frequent meals-out consumers			Moderate meals-out consumers			Low meals-out consumers		
	n = 2045			n = 496			n = 957			n = 592		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
DQI-A Overall	20.4	19.7	21.0	18.0	16.7	19.4	21.4	20.4	22.3	20.8	19.6	22.1
Diet quality component (DQc)	-6.3	-7.7	-5.0	-10.2	-12.9	-7.4	-5.2	-7.1	-3.3	-4.9	-7.5	-2.3
Diet diversity component (DDc)	44.6	44.0	45.1	43.0	41.9	44.2	45.5	44.7	46.3	44.3	43.2	45.3
Diet equilibrium component (DEc)	22.9	22.6	23.3	21.2	20.4	21.9	23.8	23.3	24.3	23.0	22.4	23.7
Diet adequacy sub-component (DAx)	53.6	53.1	54.0	52.5	51.5	53.5	54.4	53.8	55.1	53.1	52.2	54.0
Diet excess sub-component (DEx)	20.9	20.6	21.2	21.8	21.1	22.4	20.7	20.3	21.2	20.4	19.8	21.0
Age (year)	14.6	14.5	14.7	15.2	15.0	15.3	14.4	14.2	14.5	14.4	14.2	14.5
Energy (Kcal)	1758.6	1736.8	1780.3	1793.3	1743.3	1843.3	1758.0	1727.8	1788.3	1730.3	1691.7	1768.8

CI, Confidence Interval; DQI-A, Diet Quality Index for Adolescents
*** Scores presented as %**

Table 5 Regression (clustered) analysis between takeaway consumption and diet quality components and sub-components percentage score, age, food energy and house-hold income

	Unadjusted analysis								Adjusted analysis							
Frequent takeaway consumers as reference	Low B	95% CI		p	Moderate B	95% CI		p	Low B	95% CI		p	Moderate B	95% CI		p
Diet quality*																
DQI-A Overall	7.4	5.6	9.2	<0.01	3.7	2.2	5.2	<0.01	7.4	5.5	9.2	<0.01	3.5	1.9	5.1	<0.01
Diet quality component (DQc)	14.2	10.5	17.9	<0.01	6.7	3.6	9.9	<0.01	13.6	9.7	17.5	<0.01	6.5	3.2	9.9	<0.01
Diet diversity component (DDc)	4.6	3.1	6.1	<0.01	2.4	1.1	3.6	<0.01	5.1	3.5	6.7	<0.01	2.1	0.8	3.5	<0.01
Diet equilibrium component (DEc)	3.4	2.5	4.4	<0.01	2.0	1.2	2.8	<0.01	3.4	2.4	4.4	<0.01	1.8	0.9	2.7	<0.01
Diet adequacy sub-component (DAx)	1.6	0.3	2.8	0.02	1.0	-0.1	2.1	0.1	1.9	0.6	3.2	<0.01	0.7	-0.5	1.8	0.3
Diet excess sub-component (DEx)	-2.1	-3.0	-1.3	<0.01	-1.2	-1.9	-0.5	<0.01	-1.8	-2.7	-1.0	<0.01	-1.3	-2.0	-0.5	<0.01
Age (year)	0.03	-0.2	0.3	0.8	-0.1	-0.3	0.1	0.3	-0.01	-0.3	0.3	0.9	-0.2	-0.4	0.1	0.2
Energy (Kcal)	-102.4	-162.4	-42.5	<0.01	-52.8	-105.2	-0.3	0.05	-67.0	-126.6	-7.4	0.03	-43.9	-95.4	7.5	0.1

CI, Confidence Interval; DQI-A, Diet Quality Index for Adolescents
* **Scores presented as %**

Table 6 Regression (clustered) analysis between meals-out consumption and diet quality components and sub-components percentage score, age, food energy and house-hold income.

	Unadjusted analysis								Adjusted analysis							
Frequent meals-out consumers as reference	Low B	95% CI		p	Moderate B	95% CI		p	Low B	95% CI		p	Moderate B	95% CI		p
Dietary quality*																
DQI-A Overall	2.8	1.0	4.6	<0.01	3.4	1.7	5.0	<0.01	3.3	1.3	5.4	<0.01	3.5	1.7	5.3	<0.01
Diet quality component (DQc)	5.3	1.6	9.1	<0.01	5.0	1.6	8.4	<0.01	6.5	2.4	10.7	<0.01	5.4	1.7	9.0	<0.01
Diet diversity component (DDc)	1.2	-0.4	2.8	0.1	2.5	1.1	3.9	<0.01	1.8	0.1	3.5	0.04	3.0	1.4	4.5	<0.01
Diet equilibrium component (DEc)	1.9	0.9	2.8	<0.01	2.6	1.7	3.5	<0.01	1.6	0.6	2.7	<0.01	2.1	1.1	3.0	<0.01
Diet adequacy sub-component (DAx)	0.6	-0.7	1.9	0.4	1.9	0.8	3.1	<0.01	0.5	-0.9	1.9	0.5	1.5	0.2	2.7	0.02
Diet excess sub-component (DEx)	-1.4	-2.2	-0.5	<0.01	-1.0	-1.8	-0.2	<0.01	-1.2	-2.2	-0.3	<0.01	-0.9	-1.7	0.0	0.04
Age (year)	-0.8	-1.0	-0.5	<0.01	-0.8	-1.0	-0.5	<0.01	-0.8	-1.0	-0.5	<0.01	-0.7	-1.0	-0.5	<0.01
Energy (Kcal)	-64.0	-126.9	-1.0	0.05	-35.2	-93.6	23.2	0.2	-50.6	116.3	15.1	0.1	-15.1	74.6	44.5	0.6

CI, Confidence Interval; DQI-A, Diet Quality Index for Adolescents
*** Scores presented as %**

Figure 1 Number of frequent takeaway and meals-out consumers by equivalised household income quintiles