Short Communication

What options do children choose for their school lunch? Time-series and cluster analyses of food choice data from a primary school in England

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ABSTRACT

In England, more than a fifth of 10–11-year-olds live with obesity. Given its detrimental effects on health and well-being, addressing childhood obesity is critical, and understanding how children select foods is crucial to this. This study aimed to investigate children's selection of school lunches. Selection data (>11,000 transactions) for 155 schoolchildren (5–11 years), were collected from a primary school. The school offered three lunch options: meat/fish-based dish (MFD); a vegetarian dish (VEG); and sandwich/jacket potato (SJP). A time-series analysis revealed stable selection at the school population level, with consistent patterns across identical rounds of the menu cycle. There was also no difference in selections for younger and older children, and for pupils entitled to Free School Meals (FSM) and pupils who were not. Cluster analysis revealed four patterns of selection: Cluster 1 ($n = 43$) with a distinct preference for meat/fish-based dishes (76.8 % MFD, 10.5 % SJP, 12.7 % VEG); Cluster 2 ($n = 42$) with low selection of vegetarian dishes (50.2 % MFD, 36.8 % SJP, 13.0 % VEG); Cluster 3 ($n = 40$) with a tendency toward main meals (57.8 % MFD, 12.4 % SJP, 29.8 % VEG); and Cluster 4 ($n = 30$) with an assorted selection (36.8 % MFD, 27.9 % SJP, 35.3 % VEG). Cluster membership was not associated with age nor FSM entitlement. Findings, such as the stability of children's choices and the relative size of clusters point to the valuable insights afforded by selection data. These offer unique opportunities to examine children's behaviour within a school food environment, including in the longer term and as a means to inform school-based interventions.

1. Introduction

A substantial proportion (22.7 %) of 10–11-year-olds in England are living with obesity (NHS England, 2023). The aetiology of obesity is complex, involving the interaction of multiple components including environmental and dietary factors (Morales Camacho et al., 2019). In considering childhood obesity, the relevance of energy imbalance between intake and expenditure is acknowledged (Butte et al., 2007). To this end, efforts to modify dietary intake, for example, reducing the consumption of foods that are high in fat, sugar and salt have a clear role to play. Alongside due consideration for energy and nutrient content of dietary intakes, it is essential to understand more about which foods children select to eat when provided with options, and how these decisions are made. Specifically, exploring children's habitual food choices within real-world settings can contribute to our understanding of food

choice parameters and influencing factors, to then inform efforts to support children's dietary health.

In England, 60 % of primary school pupils are estimated to eat a school meal on at least four days per school week (ParentPay, Cypad & LACA, 2022). The average price of a school lunch in primary school is of the order of £2.65 (LACA, 2023) (approximately $3.37 USD). In the UK, receipt of free school meals (FSM) is a means-tested benefit and is commonly used as a proxy indicator for socio-economic disadvantage (Tierney, 2022). In addition to means-tested FSM, the Universal Infant Free School Meals (UIFSM) scheme provides all pupils in Reception, Year 1 and Year 2 (i.e. 4–7-year-olds) with free school meals (Education and Skills Funding Agency, 2024). In all cases, and regardless of whether parents pay for the meals or not, children are provided with the same meal options. The benefits of free meals in school, particularly when the school meal may be the only daily hot meal for the poorest children,

have been recognised in the political sphere (Hansard HC Deb. 7 May, 2024).

Every day, children in primary schools select their school lunch from (typically) three or four options. Little is known about how children choose from the options available. One study across four primary schools highlighted the relevance of peer influence, how older children (8–11 years) selected their school lunches more independently than younger children, and how parents perceived their children as the decision makers (Alkhunain et al., 2022). Gaining a better understanding of food choices in the real-world setting of primary schools is important, particularly given the contribution that school lunches can make to children's dietary intake. Insights can have policy and practice implications, and inform food environments and interventions to promote dietary health. Previous research investigating children's school lunches has utilised observation, questionnaires, interviews as well as photography of lunch trays (Marcano-Olivier et al., 2019). In the increasingly digitalised world, routinely collected data provide an opportunity to examine behaviour, and this is the case for food choice data from certain school catering systems. This study aimed to explore children's food choice data from the real-world setting of a primary school, to assess the patterns of children's school lunch selections, and also whether patterns were associated with child age and FSM entitlement. Further, this study looked to consider the utility of food choice data in understanding children's food choice behaviour.

2. Materials and methods

2.1. Food choice data

This longitudinal study examined food choice data comprising all pupils' school lunches selected across twenty weeks at one primary school. Data were collected via an online pre-order system, where children selected their school lunches either at school (using a digital device in their classroom, facilitated by the teacher) or remotely via an app. The school was an average-sized urban primary school, located within a decile 1 area (representing the most deprived 10 % of neighbourhoods in England) according to the index of multiple deprivation (a measure of relative deprivation). Almost a third of pupils attending the school were eligible for FSM, a higher proportion than the national average of 24.3 % (Department for Education, 2024).

School food standards in England are food-based and aim to provide children with school meals of high nutritional quality; the standards stipulate, for example, at least one portion of fruits and vegetables every day, oily fish every three weeks, and no more than two portions of deep-fried/batter-coated/breadcrumb-coated each week (The Requirements for School Food Regulations 2014, 2014). The primary school in this study operated a 3-week menu cycle (as is typical of primary schools in England), which was repeated throughout the twenty weeks. Three lunch options were offered every day: (1) a meat/fish-based dish (MFD), (2) a vegetarian dish (VEG), and (3) a sandwich or a jacket potato with a filling (SJP). In addition, children could choose side portions of

Table 1
Main meal options, side vegetables and desserts, available for children to select at lunchtime.

Lunch options	Examples
Main meal	
Meat/fish-based dish (MFD)	Fish and chips, beef lasagne, chicken pizza
Vegetarian dish (VEG)	Vegetable curry & rice, vegetarian pasta, vegetable casserole
Sandwich/jacket potato (SJP)	Ham sandwich, chicken in a bread roll
	Jacket potato with a topping, e.g. cheese, beans
Side vegetables*	Broccoli, peas, baked beans, sweetcorn
Desserts*	Chocolate sponge and custard, fruit, flapjack

* selected in the dining hall and not captured in the food choice dataset.

vegetables and a dessert. Table 1 provides an overview of the main meal options, as well as the side vegetables and desserts.

2.2. Data preparation and analysis

The food choice data were cleaned; data quality issues were identified and resolved, including the removal of cases with missing values. The inclusion criteria were applied, i.e. school meals selected by children (years 1–6, aged 5–11 years) who ate school lunches on ≥15 days (threshold determined from meal frequency distribution over the duration). The final dataset comprised 11,437 transactions, i.e. school lunch selections, made by 155 children. The number of pupils in each year group varied (range 14–38 pupils); more than two thirds of pupils in years 3–6 received FSM (69.9 %), with all pupils in years 1 and 2 receiving free school meals under the UIFSM scheme.

Time-series analysis was conducted across complete rounds of the three-week menu cycle, i.e. six rounds of 3 weeks, equating to a total of 18 weeks. Children's selection for each of the three lunch options was considered across weekdays of the six rounds of the three-week menu cycle, and was investigated at a group level, to take account of pupils not having eaten a school lunch every day. Chi-squared tests were used to determine if overall school meal selection was consistent over the six rounds of the three-week menu cycle, and consistent between corresponding days of the menu cycle week across the six rounds (e.g. each Tuesday of the first week of the menu cycle). Selections were also considered across year group and FSM entitlement.

Dietary pattern analysis is an established means of characterising individuals' diets. Cluster analysis, one specific method, can be used to determine distinct groups with differing dietary patterns. In the present study, this approach (specifically k-mean cluster analysis) was used to establish groups of individual children with similar food choice patterns. Children in clusters would have similar selections to each other but would be different from children in other clusters. For each pupil, a food choice profile was derived. This related to the percentage of a pupil's selections main meal options (i.e. %MFD, %VEG and %SJP). The cluster analysis was conducted based on %MFD and %VEG from pupils' food choice profiles; %SJP was not included given that it is directly related to %MFD and %VEG, i.e. %SJP = 100% − (%MFD + %VEG). The optimal number of clusters was determined by the silhouette method, based on maximising the average score for the cohesion of each cluster (i.e. similarity of members of the same cluster) and the separation between different clusters (i.e. distance between observations in different clusters). The mean selections for children in clusters were considered, and chi-squared tests were used to determine if patterns were associated with year group (a proxy indicator for age) and also with entitlement to FSM (a proxy indicator for socio-economic status). Statistical significance was inferred for a *p*-value <0.05; effect sizes for Cramer's V were classified by usual guidelines (Cohen, 1988).

3. Results

3.1. Time-series analysis

Overall, for the 20-week duration, meat/fish-based dishes represented more than half of transactions made (53.4 %). Selection for vegetarian dishes and sandwiches/jacket potatoes were similar, 21.6 % and 25.0 %, respectively. The menu cycle comprising three weeks, was repeated for the 20 weeks, i.e. 6 full rounds plus week 1 and week 2 for the seventh round. When considering selections across the six complete rounds of the menu cycle, a statistically significant but minor difference in patterns was detected ($\chi^2 = 38.43$, df = 10, $p < 0.001$, $\phi_C = 0.04$).

When considering selections for each individual round of the menu cycle, a statistically significant association with age was found for the rounds 4, 5, and 6 with small effect sizes (0.12, 0.08, and 0.12, respectively) indicating minor differences in patterns of selection; compared to pupils in all other years, those in Year 5 selected the highest

proportion of SJP and lowest proportion of MFD. A statistically significant association with FSM entitlement (for pupils in years 3–6, aged 7–11 years) was found for all rounds except for round 5, all with small effect sizes (0.08–0.12) indicating minor differences in patterns of selection; pupils receiving FSM made lower selections of MFD, compared to pupils not receiving FSM (50.8 % vs 60.4 %) and higher selection of SJP (28.2 % vs 20.3 %).

Fig. 1 shows the selection on each day across six rounds of the menu cycle. The selections for the same day of the menu cycle week across the six rounds were examined, (e.g. all six Tuesdays of the menu cycle second week). Significant associations were found, apart from Mondays and Wednesdays in menu cycle first week, Friday for menu cycle second week, and Monday, Wednesday and Thursday of the menu cycle third week. Effect sizes were however small – with the exception of Tuesday in menu cycle first week (0.31), Tuesday in menu cycle second week (0.34), and Thursday in menu cycle second week (0.28). This is reflected to some extent in Fig. 1, where distinct changes in children's meal selections can be seen. These corresponded with deviations from the menu cycles where the meals on offer differed from the usual planned meals. For example, on Tuesdays for the menu cycle first week, the meals for each of the three lunch options were offered as planned on Tuesday Round 4, 5 and 6 – however, the meals for all options (MFD, SJP and VEG) were changed on other Tuesdays (i.e. Tuesday of Rounds 1, 2, and 3). Likewise, school meal provision varied on some special days, and on a couple of occasions, not all options were on offer (e.g. during menu cycle second week on Thursday in Rounds 5 and 6, when no SJP was offered). Notably, for the three days where there were no deviations from the menu cycle for all rounds (i.e. Mondays of the first week, Mondays and Wednesdays of the third week), children's patterns of selection were consistent, with no significant differences observed.

3.2. K-means clustering

Cluster analysis based on children's food choice profiles was conducted with an optimal number of four clusters. The clusters, the number of children and the mean selections of each of the lunch options, are provided in Fig. 2. The first cluster comprised 43 children (28 % study sample) who predominantly selected meat/fish-based dishes (76.8 %). The second cluster had a similar number of students (42 children, 27 % sample) and was characterised by a low selection of vegetarian dishes (13.0 %). The next cluster comprising 40 children (26 % sample) exhibited a tendency toward main dishes with more than half of the selections being meat/fish-based meals (57.8 %), followed by vegetarian dishes which made up 3 in 10 selections (29.8 %). The final cluster was the smallest with 30 children (19 % sample) who selected an assortment of school lunches (36.8 %, 35.3 %, and 27.9 % for meat/fish-based dishes, vegetarian dishes, and sandwiches/jacket potato meals, respectively).

General overall trends in lunch selection were apparent, with the youngest children congregating in Cluster 1; two fifths of 5–6-year-olds were in this cluster, with a preference for meat/fish-based dishes. In contrast, more than a third of older children (9–11-year-olds) had food choice patterns dominated by a low selection of vegetarian dishes. Pupils' year group however, was not significantly associated with cluster membership when tested ($\chi^2 = 12.68$, df = 15, $p = 0.6$). When considering FSM, cluster 2 (low selection of vegetarian dishes) had a higher representation of children receiving free school meals ($n = 20$) than other clusters (cluster 1, $n = 16$; cluster 3, n = 16; cluster 4, $n = 13$). Again however, FSM for children (years 3–6), was not associated with cluster membership ($\chi^2 = 1.11$, df = 3, $p = 0.8$) (FSM is not relevant for younger children in years 1 and 2 who receive a free school meal by virtue of UIFSM).

4. Discussion

Lunch selections made by 5–11-year-old schoolchildren were

investigated using food choice data collected across twenty weeks. Children's selection of the three different school lunch options was found to be stable across the multiple rounds of the menu cycle, indicating consistency in selections made, and implying routine and habit, acknowledged as important aspects of children's food choice (Ogden & Roy-Stanley, 2020). This is pertinent for children's food choices, where the relevance of familiarity with foods, has been shown to be especially important (Aldridge et al., 2009), and where familiarity through repeated exposure to sensory properties (appearance, texture, smell, taste) is effective in children learning about foods (Mura Paroche et al., 2017) and is strongly related to children's food preferences (Cooke & Wardle, 2005). Interestingly, deviations in the menu, i.e. changes to meals on offer for the three different lunch options, were detected as fluctuations in children's selections of lunch options. Notably, the largest effect sizes were observed when deviations from the menu cycle were more substantial, and for example, when three menu options were changed on more than one occasion. This points the way to further analysis, beyond lunch options and toward exploring food characteristics that may be influential to children's food selection.

Other factors such as peer influence, catering practices and food policies in the school may also be pertinent to the stability of children's food choices. These may contribute to a level of consistency in the relevant factors and contexts, in which children are making their food choices. Such elements correspond to important influences, that operate to shape selections, as described in the food choice process model (Furst et al., 1996). Further, repeated choices themselves create momentum for the selection of the same foods in the future – which, over a life course, then determine an individual's food choice trajectory (Sobal et al., 2006).

In this study, cluster analysis was used to determine food choice patterns for mutually exclusive groups. Thus, children within the same group had similar food choice patterns to each other and different patterns to those in other groups. Four distinct patterns were identified: Cluster 1 with a preference for meat/fish-based dishes; Cluster 2 with a low selection of vegetarian dishes; Cluster 3 with a tendency toward main meals; and Cluster 4 with an assorted selection. It is interesting to note that the smallest cluster was where children had an assorted selection of menu options. The price and availability of meals was consistent across all menu options. Fewer children opting for a diverse range of selections may be related to the extent of food fussiness (rejection of many foods – both familiar and unknown) and food neophobia (rejection of unknown or novel foods), which has been reported to peak between two and six years of age (Dovey et al., 2008). Given the relevance of diet quality to children's health and wellbeing, and the importance of prioritising food diversity (Dello Russo et al., 2023), the extent to which an assorted selection of menu options may reflect a more balanced selection of foods, should be examined. Likewise, further work to understand the comparatively small number in this cluster, may support efforts related to children's willingness to try new foods.

Cluster membership in the present study was not associated with child age. Previous work on food preferences in children highlights the relevance of age in food choice, including an increase in the number of foods tried and the number of foods liked with age (Cooke & Wardle, 2005). The present study, however, was based on patterns in children's selections and likewise, related to meal options rather than specific individual meals. Indeed, the options included a wide range of different foods, such as pasta, pizza, and pastry dishes; and food items across options may hold strong similarities, e.g. vegetable curry (vegetarian dish) and chicken curry (meat/fish-based dish) – which could be better reflected with food-related properties/characteristics, incorporated within the analysis. To this end, a higher level of data granularity may provide further insight, and further work is recommended to consider patterns of children's selection of meals in this way, including any associations with age. Likewise, future work to elucidate the relevance of age would contribute to literature on children's increased autonomy with age, when selecting school meals (linked with improved literacy
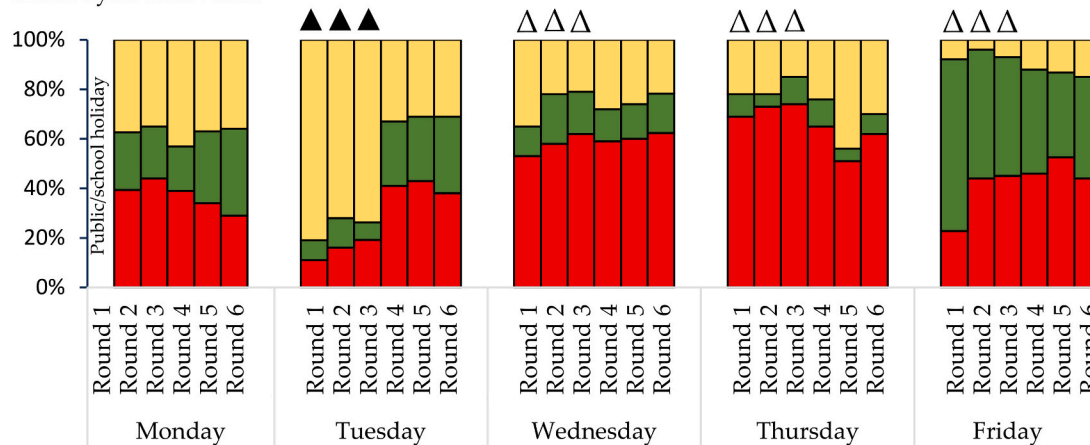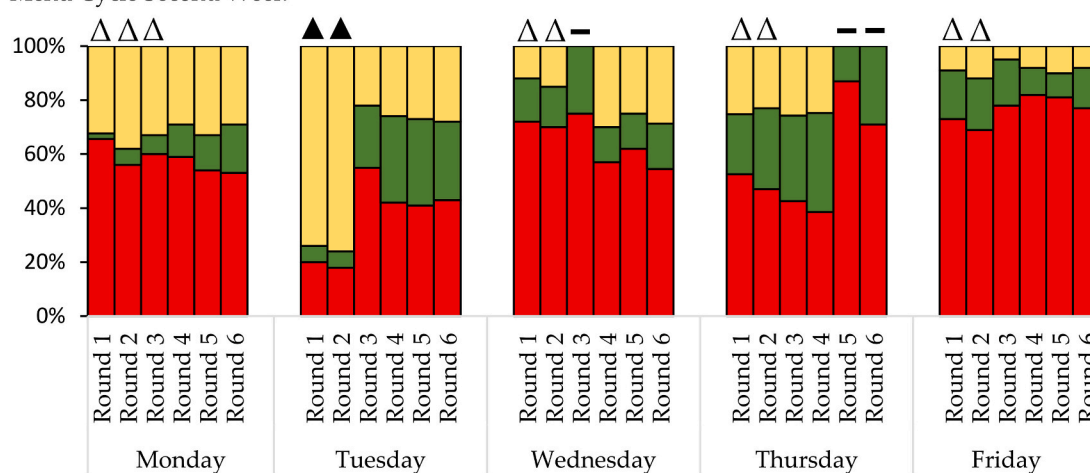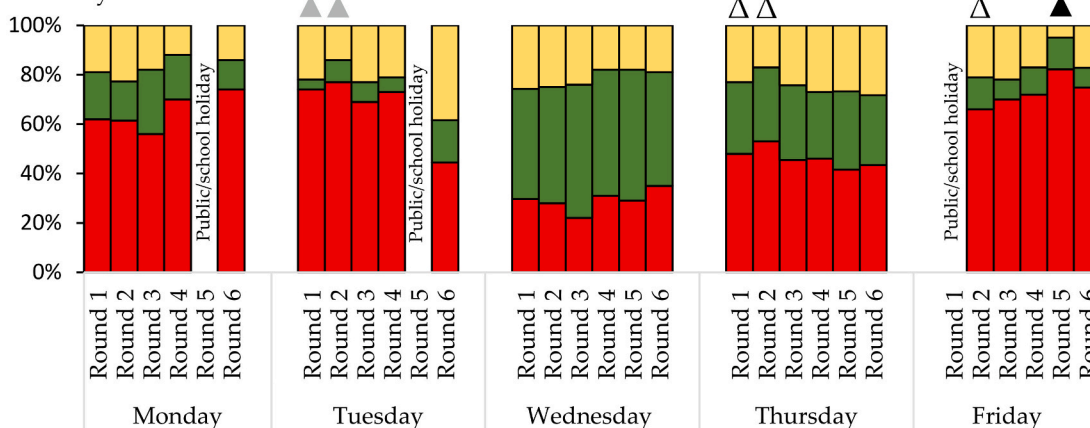
Deviations from the planned menu options are indicated by: Δ 1 option changed; ▲ 2 options changed; ▲ 3 options changed; ▬ 1 option unavailable.
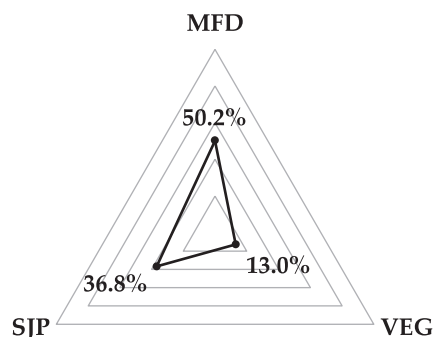
Fig. 1. School lunch selections for rounds of the 3-week menu cycle, for pupils ($n = 155$) aged 5–11 years at a primary school.
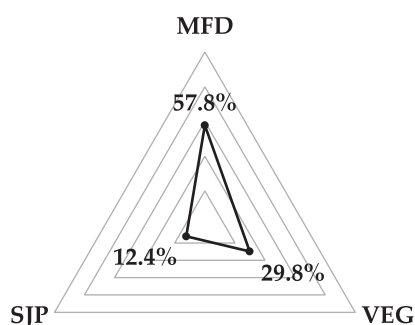
Cluster 1 n = 43
dominated by meat/fish-based dishes
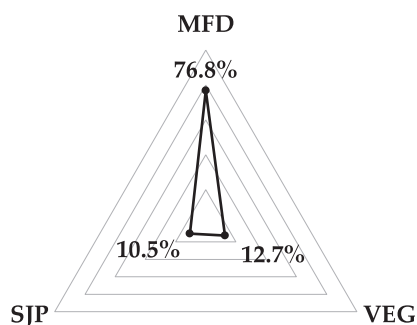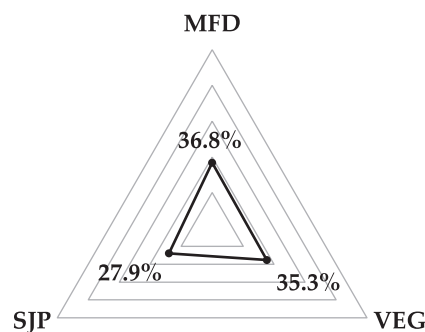

Cluster 2 n = 42
low selection of vegetarian dishes

Cluster 3 n = 40
tendency toward main dishes

Cluster 4 n = 30
assorted selection

Abbreviations: MFD, meat/fish-based dish; VEG, vegetarian dish; SJP, sandwich/jacket potato

Axes range 0 − 100%, intervals of 20%

Fig. 2. School lunch selection across clusters, for pupils (n = 155) aged 5–11 years at a primary school

and technology skills, and differences in levels of external control/influence) (Alkhunain et al., 2022).

This study's approach enabled food choice patterns to be investigated at an individual level using pupil food choice profiles. This proved to be a valuable way of understanding children's food behaviour within the real-world setting of a primary school. Specifically, insights related to the stability of choices and the relatively small size of the assorted cluster point to opportunities to broaden children's food repertoire. Evidence highlights the relevance of experiential school-based programmes, including those incorporating taste testing, cooking and gardening to improve children's willingness to taste new foods (Charlton et al., 2021).

Other strengths of the present study include the high number of transactions collected over a period of twenty weeks for 155 children. This work demonstrates the feasibility of using food choice data to provide useful insights into children's food selections. Further exploration of food choice data is recommended, for example, the inclusion of multiple consecutive academic years to track patterns of individuals in the longer term, as children progress through primary school. Likewise,

the potential of linking food choice data with the nutritional composition of the chosen meals, should be explored to understand the potential implications of choices on dietary intakes. Further, work examining food choice datasets at a larger scale across several schools is recommended. Such approaches have the potential to inform future initiatives, including school-based interventions, personalised to children, based on their food choice profiles.

The limitations of this study are acknowledged, including that the analysis relates to one primary school, an average-sized urban school with a high FSM profile; findings should be considered within this context, and further work with different schools is recommended. It is also important to emphasise that the data relate to children's selection, rather than consumption. Likewise, the data did not account for side portions of vegetables and desserts (which were not pre-selected) and related specifically to food options. Given that meals across options could hold important similarities, further work is recommended to explore choices based on more nuanced aspects, and to capture distinctions between specific food items and their food-related properties.

This study adds to the literature on children's food choices within a

school food environment. Findings provide valuable insights into children's food choice patterns, which contribute to understanding how to better support children's dietary health, when selecting school lunches. It is also important to highlight the value of interrogating food choice data and future opportunities to reveal further insights.

CRediT authorship contribution statement

Inès François: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Matthew Homer:** Writing – review & editing, Methodology, Conceptualization. **Hannah Ensaff:** Writing – review & editing, Methodology, Conceptualization.

Ethical statement

Analysis in this study related to anonymised data, collected following informed consent from parents. Ethical approval for this study was granted through the Faculty Research Ethics Committee (AREA FREC 0144).

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The authors do not have permission to share data.

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