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Patterns of sociodemographic and food practice characteristics in relation to fruit and vegetable consumption in children: results from the UK National Diet and Nutrition Survey Rolling Programme (2008–2010)

Tsz N Mak[1,*], Celia J Prynne[1], Darren Cole[1], Emily Fitt[1], Beverley Bates[2] and Alison M Stephen[1]

[1]MRC Human Nutrition Research, Elsie Widdowson Laboratory, 120 Fulbourn Road, Cambridge CB1 9NL, UK: [2]National Centre for Social Research, London, UK

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Abstract

Objective: Few studies have considered the combined effects of home-related determinants on children's diet. The present study investigated independent associations between sociodemographic and food practice (SFP) characteristics and fruit and vegetable consumption in UK children and the combined effects of SFP on consumption using pattern analysis.

Design: Diet was assessed using 4 d food diaries, SFP were collected using computer-assisted personal interview. Linear regressions were used to test associations; principal component analysis was used to identify patterns of SFP characteristics. Regression of fruit (g/d) and vegetables (g/d) *v.* component scores of each pattern were performed.

Setting: UK National Diet and Nutrition Survey Rolling Programme (2008–2010).

Subjects: Children aged 1·5–10 years (*n* 642).

Results: Significant associations were found between fruit and vegetable consumption and household socio-economic status. Pattern 1, which was positively correlated with household structure characteristics, was associated with increased fruit consumption ($P < 0{\cdot}001$). Pattern 2, characterised by positive correlations for socio-economic status, fruit availability and organic food purchase, and negatively correlated with household size and the number of children per household, was associated with higher fruit and vegetable consumption (both $P < 0{\cdot}001$). Pattern 3, characterised by high frequency of eating out and eating takeaway, was associated with a lower consumption of both fruit ($P < 0{\cdot}012$) and vegetables ($P < 0{\cdot}023$).

Conclusions: Patterns of SFP determinants may be more informative than individual characteristics in relation to dietary outcomes. Results have public health implications on the healthfulness of meals eaten out of home and in takeaways, as well as the need to reduce diet inequality in larger households with lower socio-economic status.

Keywords
Sociodemographic
National Diet and Nutrition Survey (NDNS)
Children
Fruit and vegetables
Patterns

Determinants of eating behaviour and dietary intake in children have been extensively researched, with increasing understanding of influences such as the food environment, particularly at home, where children eat most often[1]. A wide range of home-related factors such as socio-economic status (SES), affordability, availability at home and accessibility[2–5], to parental factors such as parent's education, nutritional knowledge and parental intake[3,5–9] and individual factors such as food preferences[7,8], have all been shown to relate to diet quality in children.

The most researched and consistent determinant of diet quality is the household or individual SES, which includes factors such as income, education and occupation[10–12]. Those in lower socio-economic groups tend to be less educated with lower nutritional knowledge and reduced affordability of healthier foods[11,13]. The downstream result is poorer food choices and poorer diet quality, often reflected by low fruit and vegetable (FV) consumption[14,15]. Because SES is such a strong determinant of FV consumption and diet quality, it may be possible that the relationships between home-related determinants

*Corresponding author: Email tszningmak@googlemail.com

and FV consumption are confounded or mediated by SES. Furthermore, home-related factors are likely to be correlated with each other[16]. Traditional methods to study these relationships such as multiple regression analyses have led to inconclusive results, and previous studies suggested that holistic approaches to examine combinations of related factors may be more effective in understanding dietary behaviours than individual factors alone[17,18]. This could be due to multicollinearity between variables investigated and over-adjustment of correlated confounding factors in multivariate models, leading to reduced statistical power to detect effects between exposures and diet outcomes. One way to explore the combined effects of factors rather than independent associations is to identify patterns of characteristics using principal component analysis (PCA).

The aim of the present study was to use pattern analysis to investigate associations between combinations of sociodemographic and food practice (SFP) characteristics in relation to FV consumption, in a nationally representative sample of UK children aged 1·5 to 10 years. SFP characteristics of children and their households were collected in the UK National Diet and Nutrition Survey (NDNS) 2008–2010, which included the following: household size, the number of adults and the number of children in the household; demographic characteristics including household SES, ethnicity and region; the age and sex of the main food provider of the participating children; as well as household food practice characteristics, including if organic foods were ever purchased, purchase frequencies of fruit and vegetables, fruit availability at home, eating out and eating takeaway. We hypothesised that the National Statistic Socio-economic Classification 5 (NSSEC5), an indicator of household SES based on the head of household's occupation and used in UK national surveys, was associated with these SFP factors. We also predicted that independent associations between SFP and FV consumption would attenuate when adjusted for NSSEC5 in the models. Finally, we explored empirically derived patterns of SFP using PCA, a data-driven technique to reduce the SFP variables to a smaller number of mutually exclusive patterns. These patterns were then further examined in relation to FV consumption.

Methods

Study sample and design

Data were collected from 642 children aged 1·5 to 10 years in the NDNS Rolling Programme between February 2008 and April 2010 (Years 1 and 2). The aim of NDNS is to assess food consumption, nutrient intakes and nutritional status of individuals aged 1·5+ years across the UK, with a core sample of 1000 people per year (500 adults (≥19 years) and 500 children (1·5 to 18 years)). Detailed descriptions of the sampling procedure and design have been reported[19]. Briefly, sampling was based on a random selection of postcode sectors throughout the UK; a number of addresses per sector were invited for participation by interviewers, following an initial information letter. Up to one adult and one child were selected from each participating household and a child 'boost' of addresses was included to compensate for households with no children[19]. Individual non-response weights were applied to reduce bias from differential response at the household and individual interview, and adjustment made for age, sex and regional profiles of participating individuals[20]. NDNS was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Oxfordshire A Research Ethics Committee. Written informed consent was obtained from parents of the children who participated in the survey[21].

Dietary assessment

Unweighed food diaries were used to record all food and beverages consumed over four consecutive days, with instructions given by trained interviewers at the initial visit. For bought foods such as ready meals and snacks, participants were asked to record brand names to aid identification during the coding process; for homemade dishes, recipes were recorded separately with detailed description of ingredients, quantities and cooking methods. Portion sizes were estimated using household measures and weights from food package labels. Further description and justification of the dietary assessment have been reported elsewhere[21,22]. For this age group, parents and carers filled in the food diaries, with help from other people who had looked after the children[22]. The interviewer made a brief visit (either via telephone or in person) during the recording period to check for compliance and answer queries. Upon completion of the diary, the interviewer returned to collect the food diary and checked for any missing information[22]. To be considered fully productive, participants had to record their intakes for three days or more. Food diaries were returned to the Medical Research Council – Human Nutrition Research and were coded by trained diet coders using the in-house dietary assessment software, Diet in Nutrients out, with nutrient values provided by the UK NDNS Nutrient Databank.

Disaggregation of fruit and vegetable consumption

Portion sizes of discrete fruit items and discrete vegetable items were determined using the publication *Food Portion Sizes*[23]. To quantify consumption of fruit and vegetables more accurately, disaggregation of mixed dishes was undertaken. The method adopted to disaggregate food codes in NDNS has been described previously[24]. Essentially, proportions of fruit and vegetables in composite dishes were calculated in three main ways: (i) manufactured product information from packaging; (ii) standard recipes from

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McCance and Widdowson's The Composition of Foods[25]; and (iii) homemade recipes from respondents' food diaries. For products that contain dried fruit and vegetables, such as soup powders, dried FV content was scaled up using the water content of the fresh equivalent. The amounts of disaggregated and discrete fruit and vegetables consumed by each participant per day were summed and the mean intakes of fruit (g/d) and vegetables (g/d) over the recording period were calculated per person.

Computer-assisted personal interview

A computer-assisted personal interview (CAPI) was conducted face-to-face by the interviewer during the initial visit to the participant's home. The CAPI consisted of three main elements: (i) a household structure interview; (ii) a main food provider (MFP) interview; and (iii) an individual interview. Together these gathered information on demographics, household composition, shopping and food preparation practices, cooking skills and facilities at home. Information on employment and income of the household reference person, defined as the person in whose name the property is owned or rented with the highest income, was used to determine the socio-economic classification of the household[21]. For this age group, the questions in the CAPI were answered on behalf of the child by the MFP, defined as the person best placed to answer questions about food purchase and preparation for the participant, who was usually the mother of the child. Details of the CAPI and the full questionnaire have been reported[19,26].

Sociodemographic variables

Variables relating to sociodemographic characteristics and household structure were collected in the first part of the CAPI. NSSEC5 was used as the household SES indicator for the survey[27], which was based on occupation and included five sub-categories: (i) managerial and professional; (ii) intermediates; (iii) small employers and own account workers; (iv) lower supervisory and technical; and (v) routine, manual, never worked, long-term unemployment. Since 2001, NSSEC has been used as the main measure of household SES for all official statistics and surveys in the UK. NSSEC takes into account details of employment status of the household reference person (whether an employer, self-employed or employee; whether a supervisor, manager, etc.), and is seen as superior to other social classification measures as it has been constructed to determine employment relations and conditions of occupation, to show the structure of socio-economic position in modern societies and to explain variations in social behaviour and other social phenomena[28]. Ethnicity was recorded as white or non-white. Six categories were used to describe region: (i) England: North; (ii) England: Central/Midlands; (iii) England: South (including London); (iv) Scotland; (v) Wales; and (vi) Northern Ireland. For household structure, information was collected on: the size of the household (on the scale of 2, 3, 4 and 5+); the number of adults per household (1, 2 and 3+); and the number of children per household (1, 2, 3 and 4+). The level of household income was asked in the questionnaire, but due to a high percentage of non-responses, this variable was not used in the analysis. Information on parent's education level was not collected in NDNS. For adults participating in NDNS, questions related to education were asked but not for children, and therefore this variable could not be used in the current analysis.

Food practice variables

The MFP interview in the CAPI captured a number of variables related to food practices at home. Specific fruit and vegetable indicators were recorded, including frequency of fruit and vegetable purchase ('<3 times per month', 'weekly', '2 or 3 times per week', 'daily') and frequency of fruit availability at home ('never', 'weekly', 'most of the time'). Respondents were also asked if they have ever purchased organic foods (yes, no), how frequently they eat out ('rarely or never', 'once or twice per month', 'more than once per week') and the frequency of eating takeaway ('rarely or never', 'once or twice per month', 'more than once per week'). Age and sex of the MFP were included in the analyses.

Statistical analysis

All analyses were performed using the Stata statistical software package release 11. Descriptive statistics of continuous variables were expressed as means and standard deviations. Distributions of the categorical variables were described in absolute frequencies and percentages. The χ^2 test was used to test for associations between NSSEC5 and individual SFP variables, except for MFP age, which was a continuous variable; ANOVA was used instead to test for association. Independent associations between the SFP variables and fruit consumption (g/d) and vegetable (g/d) consumption were determined using linear regression analysis, with all models adjusted for age and sex of the child. Patterns of the variables were identified using PCA. PCA is a statistical data-reduction technique that reduces a large number of variables into a smaller number of uncorrelated linear combinations of variables that contain most of the variance of the sample[29]. PCA is scale sensitive[30] and only variables of continuous, ordinal and binary nature were included in the analysis; hence the variable 'region' was removed from analyses. The variable MFP sex was also removed since only 7% of MFP were male. Eleven variables were therefore entered in the PCA: household size, number of adults per household, number of children per household, NSSEC5, ethnicity, MFP age, frequency of fruit availability, frequency of FV purchase, organic purchase, frequency of eating out and frequency of eating takeaway. Variables with component loadings $>\pm 0{\cdot}3$ were considered to be correlated highly with the construction of the pattern. The screeplot was

used to decide on the number of patterns to retain for subsequent analyses. Pattern scores were calculated for each participant for each pattern retained and were regressed *v.* fruit (g/d) and vegetable (g/d) consumption. Age and sex of the child were adjusted in the final models. Survey commands (svy) were used throughout to account for the multistage survey design and non-response weighting was applied in the regression analyses.

Results

Sample characteristics

Table 1 shows the basic characteristics of the sample population. Fifty-one per cent of children were male. Mean household size was 3·8 (SD 1·1) persons, with two adults (SD 0·7) and two children (SD 0·8) on average. The majority of the sample was white, from England South (40·5 %), and 41 % of the household reference persons had managerial and professional occupations. In terms of food practice characteristics, the majority of the MFP were female, with a mean age of 35 (SD 7·2) years. Most MFP purchased FV weekly or 2 or 3 times per week, and indicated that fruit were available at home most of the time. About 70 % of children ate out at least once per month, while approximately 50 % of children rarely or never ate takeaway.

Household socio-economic status and sociodemographic and food practice characteristics

NSSEC5 was associated with seven out of twelve SFP variables (Table 2), including the number of adults per household, MFP age, frequency of fruit availability, organic food purchase (all $P < 0{\cdot}001$), household size, frequency of eating takeaway (both $P < 0{\cdot}01$) and frequency of FV purchase ($P < 0{\cdot}05$).

Independent associations between sociodemographic and food practice characteristics and fruit and vegetable consumption

Child's age was associated with fruit consumption and vegetable consumption, where fruit consumption decreased as age increased ($P = 0{\cdot}002$) with the reverse seen for vegetables ($P < 0{\cdot}001$; Table 3). Compared with single-adult households (reference), children in households with two adults consumed approximately 21·3 g more fruit per day ($P = 0{\cdot}01$); however the relationship was not significant when adjusted for NSSEC5. On the other hand, vegetable consumption was 29·7 g/d lower ($P = 0{\cdot}037$) in households with more than three adults after adjusting for NSSEC5. Differences in consumption were seen in different household socio-economic classifications, where children in the highest NSSEC5 group (managerial and professional) consumed significantly more fruit and vegetables daily (both $P < 0{\cdot}001$) than those from the lowest NSSEC5 group (reference). Other sociodemographic characteristics were not significantly related to FV consumption.

Associations were seen between food practice characteristics and FV consumption in children (Table 4) and most remained significant after adjusting for NSSEC5. Fruit consumption increased as MFP age increased ($P = 0{\cdot}007$). Those who reported to have ever bought organic food consumed 24·8 g more fruit ($P = 0{\cdot}001$) and 14·6 g more vegetables ($P < 0{\cdot}019$) per day than those who had never purchased organic food (reference) after adjusting for NSSEC5 and age and sex of children (fully adjusted model). Higher fruit consumption was also seen in children in the fully adjusted model where the MFP reported to purchase fruit and vegetables frequently (2 or 3 times per week ($P = 0{\cdot}001$) or once daily ($P = 0{\cdot}025$)) and had fruit available at home weekly or most of the time (both $P < 0{\cdot}001$). Those who ate takeaway more than once per week consumed 32·2 g less fruit ($P < 0{\cdot}001$) and 20·4 g less vegetables ($P = 0{\cdot}028$) per day than those rarely or never ate takeaway (reference) in the fully adjusted model.

Pattern analysis

Of the eleven principal components (patterns) identified from the PCA, three were retained for subsequent analyses, where they explained approximately 46 % of total variance of the data. The loadings of each variable for the three patterns were shown in Table 5.

The first pattern described greater correlations with household structure, where higher positive correlations were seen for household size, number of children and number of adults per household. For each unit of increase in pattern score, children significantly increased consumption of fruit by 9·5 g/d ($P < 0{\cdot}001$); no difference was observed for vegetables (Table 6). The second pattern was characterised by positive correlations for NSSEC5, fruit availability and organic food purchase, and in contrast to pattern 1, this pattern was negatively correlated with household size and the number of children per household. For this pattern, fruit and vegetable consumption increased significantly by 16·8 g/d and 8·1 g/d, respectively, per unit increase of pattern score (both $P < 0{\cdot}001$). Lastly, the third pattern explained positive correlations with frequencies of eating out and eating takeaway, as well as negative correlation with ethnicity, indicating those who correlated higher with this pattern were more likely to be white than non-white. This pattern was associated with a lower consumption of both fruit ($P = 0{\cdot}012$) and vegetables ($P = 0{\cdot}023$).

Discussion

The present study has demonstrated household SES was significantly associated with a number of SFP variables in this nationally representative sample of UK children aged 1·5 to 10 years. There were very few associations

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Table 1 Characteristics of the sample population: children (*n* 642) aged 1·5–10 years, UK National Diet and Nutrition Survey Rolling Programme (2008–2010)

	n		%
Sociodemographic characteristics			
Child's age group (years)			
1·5–3	219		34·1
4–6	192		29·9
7–10	231		36·0
Child's sex			
Male	327		50·9
Household size			
Mean		3·8	
SD		1·1	
2	43		6·7
3	213		33·2
4	256		39·9
5+	130		20·3
Number of adults in household			
Mean		2·0	
SD		0·7	
1	106		16·5
2	479		74·6
3+	57		8·9
Number of children in household			
Mean		1·9	
SD		0·8	
1	228		35·5
2	300		46·7
3	93		14·5
4+	21		3·3
NSSEC5			
Managerial and professional	263		41·0
Intermediates	50		7·8
Small employers and own account workers	77		12·0
Lower supervisory and technical	68		10·6
Routine, manual, never worked, long-term unemployment	184		28·7
Ethnicity			
White	537		83·6
Non-white	105		16·4
Region			
England: North	158		24·6
England: Central/Midlands	107		16·7
England: South (incl. London)	260		40·5
Scotland	49		7·6
Wales	46		7·2
Northern Ireland	22		3·4
Home characteristics			
MFP sex			
Female	597		93·0
MFP age (years)			
Mean		34·9	
SD		7·1	
Frequency of purchasing FV			
<3 times/month	29		4·5
Weekly	295		46·0
2 or 3 times per week	307		47·8
Daily	11		1·7
Frequency of fruit availability at home			
Never	2		0·3
Weekly	46		7·2
Most of the time	594		92·5
Purchase organic food			
No	333		51·9
Yes	309		48·1
Frequency of eating out			
Rarely or never	198		30·8
Once or twice per month	319		49·7
More than once per week	125		19·5
Frequency of eating takeaway			
Rarely or never	322		50·2
Once or twice per month	217		33·8
More than once per week	103		16·0

NSSEC5, National Statistic Socio-economic Classification 5; MFP, main food provider; FV, fruit and vegetables.

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Table 2 Associations between NSSEC5 and SFP characteristics: children (*n* 642) aged 1·5–10 years, UK National Diet and Nutrition Survey Rolling Programme (2008–2010)

	NSSEC5* (lowest to highest)						
	1	2	3	4	5	Total	
Sociodemographic characteristics	%						*P* value†
Child's age group (years)							
1·5–3 (*n* 219)	28·8	9·6	11·9	8·2	41·6	100·0	
4–6 (*n* 192)	27·1	11·5	10·9	6·8	43·8	100·0	
7–10 (*n* 231)	29·9	10·8	13·0	8·2	38·1	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·973
Child's sex							
Male (*n* 327)	25·7	12·2	11·3	7·3	43·4	100·0	
Female (*n* 315)	31·8	8·9	12·7	8·3	38·4	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·271
Household size							
2 (*n* 43)	39·5	18·6	4·7	18·6	18·6	100·0	
3 (*n* 213)	28·6	9·4	9·9	8·9	43·2	100·0	
4 (*n* 256)	27·7	11·3	11·3	6·3	43·4	100·0	
5+ (*n* 130)	26·9	8·5	19·2	5·4	40·0	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·005
Number of adults in household							
1 (*n* 106)	51·9	12·3	3·8	15·1	17·0	100·0	
2 (*n* 479)	23·2	10·4	13·2	6·1	47·2	100·0	
3+ (*n* 57)	31·6	8·8	17·5	8·8	33·3	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	<0·001
Number of children in household							
1 (*n* 228)	24·6	13·6	9·7	9·2	43·0	100·0	
2 (*n* 300)	32·0	8·7	12·0	7·7	39·7	100·0	
3 (*n* 93)	25·8	7·5	16·1	5·4	45·2	100·0	
4+ (*n* 21)	38·1	19·1	19·1	4·8	19·1	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·163
Ethnicity							
White (*n* 537)	27·6	9·7	12·7	8·2	41·9	100·0	
Non-white (*n* 105)	34·3	15·2	8·6	5·7	36·2	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·161
Region							
England: North (*n* 158)	33·5	8·9	6·3	7·6	43·7	100·0	
England: Central/Midlands (*n* 107)	28·0	11·2	15·0	10·3	35·5	100·0	
England: South (incl. London) (*n* 260)	25·0	10·0	14·2	7·3	43·5	100·0	
Scotland (*n* 49)	28·6	12·2	8·2	6·1	44·9	100·0	
Wales (*n* 46)	28·3	15·2	17·4	6·5	32·6	100·0	
Northern Ireland (*n* 22)	40·9	13·6	9·1	9·1	27·3	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·576

	NSSEC5* (lowest to highest)						
Food practice characteristics	1	2	3	4	5	Total	*P* value
MFP age (years)							
Mean	32·4	34·1	36·1	34·0	36·6	34·9	<0·001‡
SD	7·8	6·6	7·5	6·6	6·0	7·1	
n	184	68	77	50	263	642	
	%						
MFP sex							
Male (*n* 45)	24·4	13·3	6·7	11·1	44·4	100·0	
Female (*n* 597)	29·0	10·4	12·4	7·5	40·7	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·624
Frequency of purchasing FV							
<3 times per month (*n* 29)	37·9	6·9	20·7	10·3	24·1	100·0	
Weekly (*n* 295)	30·9	14·2	9·8	6·8	38·3	100·0	
2 or 3 times per week (*n* 307)	26·1	7·8	13·7	8·8	43·7	100·0	
Daily (*n* 11)	18·2	0·0	0·0	0·0	81·8	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·018
Frequency of fruit availability at home							
Never (*n* 2)	50·0	0·0	0·0	50·0	0·0	100·0	
Weekly (*n* 46)	60·9	10·9	8·7	10·9	8·7	100·0	
Most of the time (*n* 594)	26·1	10·6	12·3	7·4	43·6	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	<0·001

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Table 2 *Continued*

	NSSEC5* (lowest to highest)						
	1	2	3	4	5	Total	
Food practice characteristics	%						*P* value
Purchase organic food							
No (*n* 333)	39·6	10·8	10·2	9·9	29·4	100·0	
Yes (*n* 309)	16·8	10·4	13·9	5·5	53·4	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	<0·001
Frequency of eating out							
Rarely or never (*n* 198)	35·4	11·6	12·6	8·6	31·8	100·0	
Once or twice per month (*n* 319)	25·4	11·0	11·3	8·5	43·9	100·0	
More than once per week (*n* 125)	26·4	8·0	12·8	4·8	48·0	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·087
Frequency of eating takeaway							
Rarely or never (*n* 322)	22·1	9·9	11·8	7·8	48·5	100·0	
Once or twice per month (*n* 217)	32·7	10·1	12·0	8·8	36·4	100·0	
More than once per week (*n* 103)	40·8	13·6	12·6	5·8	27·2	100·0	
Total (*n* 642)	28·7	10·6	12·0	7·8	41·0	100·0	0·003

NSSEC5, National Statistic Socio-economic Classification 5; SFP, sociodemographic and food practice; MFP, main food provider; FV, fruit and vegetables.
*NSSEC5 categories were as follows: 1 = routine, manual, never worked, long-term unemployment; 2 = lower supervisory and technical occupations; 3 = small employers and own account workers; 4 = intermediate occupations; 5 = managerial and professional occupations.
†Associations between SFP characteristics and NSSEC5 examined using χ^2 tests. *P* values significant at $P < 0{\cdot}05$.
‡Association between MFP age and NSSEC5 tested using ANOVA. *P* value significant at $P < 0{\cdot}05$.

between sociodemographic variables and FV consumption, but several food practice characteristics were significantly related to FV consumption independent of household SES. Finally, through PCA, three distinct patterns of SFP characteristics were identified, where each pattern was uniquely associated with FV consumption.

While our results have shown that household SES is indeed a strong predictor of FV consumption, especially when comparing the highest NSSEC5 group with the lowest group, our hypothesis that associations between SFP characteristics and FV consumption were confounded by SES was only partially supported. Attenuation of the significance level was seen for fruit consumption in relation to only two variables after adjustment for NSSEC5 ('two adults per household' and 'takeaway once or twice per month'), while vegetable consumption became significantly associated with 'three or more adults per household'. The majority of the food practice characteristics remained significantly associated with FV consumption even after adjusting for NSSEC5. Therefore, several food practice characteristics were important in predicting FV consumption irrespective of household socio-economic situation. Factors other than household SES may be important in driving food practices and decisions to provide fruit and vegetables to children. As suggested by previous studies, these could be parent's education, nutritional knowledge and income or affordability, but they were not tested in the current analysis.

Our results suggest that children from households where fruit and vegetables were frequently purchased have fruit frequently available at home, infrequently eat takeaway, and have higher daily FV consumption. Similar findings are seen in the literature on home food environment, where home availability and accessibility of fruit and vegetables are important determinants of consumption[5,31], while high availability of unhealthy foods is associated with higher consumption of those[8,32]. It has been suggested that adolescents in two-parent families have better eating behaviours such as consumption of fruit and vegetables and regular breakfast compared with single-parent families[4,33], although studies did not control for the effects of SES on family structure. Our results also showed that two-adult households had higher fruit consumption, although the relationship was no longer significant after adjusting for SES. It has been found previously that as age increases, children tend to consume less fruit as well as vegetables[34]. Our findings suggested that children's age was inversely associated with fruit consumption only, but not for vegetables where a positive relationship was seen. The contrasting result may reflect different methodologies used in measuring FV consumption between studies. Some studies have measured fruit and vegetables together as one food category using FFQ or other means of dietary assessment, while in the present study they were assessed using food diaries, disaggregated from mixed dishes and analysed separately, as previous results indicate that fruit consumption and vegetable consumption are two distinct eating behaviours[35,36].

Households with three adults or more appeared to be unfavourable for children's vegetable consumption independent of SES. To our knowledge, this has not been tested before. MFP age was found to be a strong positive predictor of FV consumption, which partially supports the finding from a recent study where maternal age was associated with higher pattern scores on the 'healthy' diet[37]; however, at odds with another study on maternal age at delivery and food consumption in pre-school

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Table 3 Independent associations between sociodemographic characteristics and FV consumption: children (*n* 642) aged 1·5–10 years, UK National Diet and Nutrition Survey Rolling Programme (2008–2010)

	Fruit*			Fruit†			Vegetables*			Vegetables†		
Sociodemographic characteristics	β	*P* value	95 % CI	β	*P* value	95 % CI	β	*P* value	95 % CI	β	*P* value	95 % CI
Child's age	−3·55	0·002	−5·76, −1·35	–	–	–	5·86	<0·001	3·67, 8·00	–	–	–
Child's sex												
Male	Reference	–	–	–	–	–	Reference	–	–	–	–	–
Female	6·27	0·417	−8·95, 21·48	–	–	–	−0·68	0·917	−13·50, 12·14	–	–	–
Household size												
2	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
3	11·59	0·441	−18·04, 41·22	6·15	0·676	−22·86, 35·15	−3·23	0·755	−23·67, 17·21	−6·84	0·518	−27·65, 13·98
4	18·17	0·232	−11·71, 48·06	11·72	0·423	−17·10, 40·53	−3·54	0·725	−23·34, 16·27	−7·81	0·454	−28·36, 12·74
5+	12·68	0·402	−17·13, 42·49	6·45	0·658	−22·30, 35·20	−9·00	0·387	−29·49, 11·48	−13·13	0·215	−33·95, 7·70
Number of adults in household												
1	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
2	21·27	0·010	5·11, 37·44	10·13‡	0·249	−7·15, 27·41	−4·82	0·550	−20·70, 11·06	−14·12	0·089	−30·41, 2·18
3+	7·95	0·567	−19·45, 35·34	−2·85	0·836	−30·10, 24·39	−21·99	0·134	−50·83, 6·85	−29·72§	0·037	−57·65, −1·80
Number of children in household												
1	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
2	6·13	0·445	−9·71, 21·98	8·20	0·308	−7·64, 24·04	0·95	0·879	−11·41, 13·31	2·04	0·753	−10·74, 14·82
3	3·61	0·742	−17·99, 25·20	2·58	0·812	−18·79, 23·96	−5·99	0·491	−23·11, 11·13	−6·83	0·422	−23·59, 9·93
4+	−7·85	0·567	−34·88, 19·17	−3·61	0·804	−32·41, 25·18	−8·54	0·588	−39·65, 22·57	−4·83	0·765	−36·68, 27·02
NSSEC5												
Routine, manual, never worked, long-term unemployment	Reference	–	–	–	–	–	Reference	–	–	–	–	–
Lower supervisory and technical	20·40	0·046	0·38, 40·42	–	–	–	9·97	0·350	−11·03, 30·97	–	–	–
Small employers and own account workers	40·04	0·001	17·40, 62·69	–	–	–	15·27	0·157	−5·94, 36·49	–	–	–
Intermediates	34·23	0·033	2·77, 65·69	–	–	–	4·37	0·645	−14·32, 23·06	–	–	–
Managerial and professional	39·40	<0·001	24·06, 54·75	–	–	–	26·11	<0·001	12·07, 40·16	–	–	–
Ethnicity												
White	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
Non-white	−7·96	0·382	−25·90, 9·97	−6·15	0·478	−23·24, 10·94	2·95	0·734	−14·18, 20·07	4·67	0·585	−12·21, 21·56
Region												
England: North	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
England: Central/Midlands	4·22	0·748	−21·63, 30·06	1·42	0·907	−22·62, 25·46	3·03	0·763	−16·74, 22·80	2·55	0·807	−18·07, 23·17
England: South (incl. London)	7·03	0·485	−12·80, 26·86	3·43	0·712	−14·90, 21·77	−1·02	0·889	−15·44, 13·40	−2·18	0·766	−16·60, 12·25
Scotland	18·02	0·215	−10·56, 46·60	17·14	0·268	−13·33, 47·60	−1·21	0·920	−24·95, 22·53	−1·69	0·882	−24·18, 20·81
Wales	4·26	0·759	−23·15, 31·67	1·85	0·880	−22·37, 26·07	15·06	0·353	−16·88, 47·01	15·66	0·318	−15·19, 46·51
Northern Ireland	−9·97	0·586	−46·08, 26·14	−6·91	0·687	−40·75, 26·93	−15·79	0·501	−62·03, 30·45	−12·89	0·568	−57·43, 31·65

FV, fruit and vegetable; NSSEC5, National Statistic Socio-economic Classification 5.
*Model adjusted for age and sex.
†Model adjusted for age, sex and NSSEC5.
‡Variable category became non-significant after adjusting for NSSEC5.
§Variable category became significant after adjusting for NSSEC5.

Table 4 Independent associations between food practice characteristics and FV consumption: children (*n* 642) aged 1·5–10 years, UK National Diet and Nutrition Survey Rolling Programme (2008–2010)

	Fruit*			Fruit†			Vegetables*			Vegetables†		
Food practice characteristics	β	*P* value	95 % CI	β	*P* value	95 % CI	β	*P* value	95 % CI	β	*P* value	95 % CI
MFP age	2·23	<0·001	1·11, 3·34	1·53	0·007	0·42, 2·64	0·30	0·509	−0·60, 1·20	−0·25	0·583	−1·16, 0·66
MFP sex												
Male	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
Female	8·64	0·378	−10·67, 27·96	8·69	0·375	−10·59, 27·97	15·37	0·064	−0·89, 31·63	15·83	0·060	−0·68, 32·33
Frequency of purchasing FV												
<3 times per month	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
Weekly	21·28	0·095	−3·74, 46·30	18·01	0·140	−5·96, 41·98	−25·29	0·036	−48·88, −1·70	−29·31	0·021	−54·15, −4·48
2 or 3 times per week	45·75	0·001	20·20, 71·29	39·53	0·001	15·39, 63·67	−17·96	0·138	−41·74, 5·82	−23·28	0·065	−48·03, 1·46
Daily	87·58	0·007	24·14, 151·03	80·51	0·025	10·06, 150·95	10·89	0·481	−19·58, 41·35	0·98	0·955	−33·03, 35·00
Frequency of fruit availability at home												
Never	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
Weekly	51·68	<0·001	26·02, 77·34	48·85	<0·001	28·26, 69·44	13·02	0·612	−37·52, 63·56	9·82	0·693	−39·21, 58·84
Most of the time	115·31	<0·001	97·24, 133·38	100·42	<0·001	86·16, 114·68	21·97	0·358	−25·15, 69·08	9·21	0·691	−36·54, 54·96
Purchase organic food												
No	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
Yes	31·74	<0·001	17·11, 46·38	24·77	0·001	9·87, 39·66	19·52	0·001	8·01, 31·03	14·56	0·019	2·44, 26.68
Frequency of eating takeaway												
Rarely or never	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
Once or twice per month	−18·74	0·012	−33·24, −4·23	−14·69‡	0·052	−29·48, 0·10	−7·10	0·329	−21·41, 7·22	−4·33	0·549	−18·54, 9·89
More than once per week	−39·16	<0·001	−57·55, −20·77	−32·20	0·001	−51·64, −12·76	−25·14	0·007	−43·38, −6·90	−20·36	0·028	−38·46, −2·27
Frequency of eating out												
Rarely or never	Reference	–	–	Reference	–	–	Reference	–	–	Reference	–	–
Once or twice per month	13·67	0·130	−4·08, 31·43	9·96	0·271	−7·87, 27·79	5·57	0·461	−9·31, 20·44	2·56	0·732	−12·17, 17·29
More than once per week	8·02	0·489	−14·81, 30·85	4·80	0·665	−17·07, 26·67	1·49	0·875	−17·20, 20·18	−1·33	0·889	−20·10, 17·45

FV, fruit and vegetable(s); MFP, main food provider; NSSEC5, National Statistic Socio-economic Classification 5.
*Model adjusted for age and sex.
†Model adjusted for age, sex and NSSEC5.
‡Variable category non-significant after adjusting for NSSEC5.

Table 5 Eigenvalues, percentage of variance and the component loadings for the three patterns retained

	Pattern 1	Pattern 2	Pattern 3
Eigenvalue	2·243	1·683	1·180
% of variance*	20·4	15·3	10·7
Component loadings for each pattern			
Household size	0·5817†	−0·3394†	0·0603
Number of adults per household	0·4278†	−0·0106	0·2346
Number of children per household	0·4280†	−0·4233†	−0·1021
NSSEC5	0·2245	0·4715†	−0·0615
Ethnicity	0·0497	−0·1645	−0·3077†
MFP age	0·2997	0·2336	0·2232
Frequency of FV purchase	0·2080	0·2456	−0·2697
Frequency of fruit availability	0·2224	0·3007†	−0·0941
Ever bought organic food	0·2384	0·3547†	−0·0830
Frequency of eating out	0·0047	0·2880	0·5496†
Frequency of eating takeaway	−0·0563	−0·2049	0·6261†

NSSEC5, National Statistic Socio-economic Classification 5; MFP, main food provider; FV, fruit and vegetable(s); SFP, socio-demographic and food purchase; PCA, principal component analysis.
*Percentage of variance explained by SFP variables in the PCA pattern scores.
†Component loading of variable ≥±0·30 considered to be highly correlated with pattern.

Table 6 Regression of pattern scores for patterns 1, 2 and 3 on fruit consumption (g/d) and vegetable consumption (g/d): children (*n* 642) aged 1·5–10 years, UK National Diet and Nutrition Survey Rolling Programme (2008–2010)

	Fruit			Vegetables		
	β*	*P* value	95 % CI	β	*P* value	95 % CI
Pattern 1	9·51	<0·001	4·82, 14·20	0·82	0·709	−3·50, 5·14
Pattern 2	16·81	<0·001	12·15, 21·48	8·08	<0·001	3·71, 12·45
Pattern 3	−8·63	0·012	−15·38, −1·89	−7·23	0·023	−13·47, −0·99

*β, beta coefficient representing an increase of consumption (g/d) per unit increase of pattern score.

children, where children of mothers aged less than 25 years were less likely to eat fruit and while those of mothers aged 25–29 years were less likely to eat vegetables[38]. Older MFP may have greater knowledge and experience in providing food for children than those younger and less experienced, thus making healthier choices for children compared with their younger counterparts. FV consumption in children was also predicted by organic food purchases. Organic foods are sometimes perceived to be superior and healthier than non-organic, even though they are also more expensive[39]. Organic buyers may be more conscious of the health of their children than those who never buy organic foods[40].

We have demonstrated a novel approach to studying the combined effects of correlated SFP characteristics with FV consumption, using an exploratory data-driven technique, through which we identified three distinct patterns in NDNS children. The first pattern was characterised mainly by household structure variables. In the independent analysis, very few associations were seen between household structure characteristics and FV consumption; however as a pattern, household size was associated with fruit consumption, with children from larger households having higher fruit consumption. The results suggested that a higher ratio of parents to children in the household may be more important to predict children's fruit consumption than just the size of household alone. The second pattern was also of considerable interest, as it corresponded well with a combination of household factors and food practice variables. In contrast to the first pattern regarding household size, the pattern described a fewer number of children from smaller households. It also described higher-SES households with greater fruit availability and organic food purchases. These characteristics reflected households with greater affordability of fruit and vegetables for their children's diet, and were related to higher FV consumption. The third pattern was driven by the practice of a high frequency of eating out and takeaway food. Although the independent association of eating out was not significant, the pattern suggested that the overall behaviour of frequent eating out and takeaway was unfavourable for both fruit consumption and vegetable consumption. This finding resonates with previous literature on fast food and takeaway and diet quality[41,42].

The strength of the present study lies in the high quality of the data, collected from a nationally representative sample of UK children aged 1·5–10 years, using 4 d diet diaries and comprehensive interviews delivered by trained interviewers. The measurement of FV consumption after disaggregation provided more complete dietary data than other studies[24]. The use of PCA on SFP data advances knowledge of determinants of FV consumption within the

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home setting, demonstrating combined effects of SFP characteristics in relation to FV consumption. A further advantage of PCA was to minimise the problem of reduced statistical power of highly correlated factors analysed together; we have demonstrated the differences in analysing the SFP characteristics using independent regression with adjustment of household SES *v.* patterns of these characteristics on FV consumption in children.

There are, however, limitations associated with the study. PCA is a data-driven technique and the patterns produced are dependent on the data collected and sample specific. If the same technique is applied to another sample, the patterns produced may not be directly comparable to our results. PCA is known to be inflexible in dealing with measurement error-prone data, as well as non-continuous or ordinal data. As a result, only certain variables were analysed in the current study. Another limitation is the use of NSSEC5 as proxy of SES. Although NSSEC5 is considered a superior measure of household SES compared with measures used in previous national surveys, it does not reflect other important aspects of SES including household income and parental education. These have been shown to impact eating behaviour and dietary intake and therefore may have contributed to residual confounding in the results. Furthermore, because NDNS is nationally representative of the UK population, the majority of children in the current study were white. In addition, the children sample was from relatively high socio-economic groups. These factors may have limited the findings and the patterns derived from PCA, as previous studies have suggested that low consumption due to low availability and accessibility of fruit and vegetables tends to occur in those from lower socio-economic backgrounds and possibly in ethnic minority groups.

The study provides new insights on relationships between patterns of SFP characteristics in relation to FV consumption in a nationally representative sample of UK children, and has shown combined effects of these characteristics on FV consumption. While the method used was exploratory and the results may not apply to other populations, the findings add value to current perspectives on determinants of children's diet quality at the household level. Furthermore, the results have implications for public health practice and policy. Households who eat out and eat takeaways frequently are at higher risks of low FV consumption. The government should encourage food industry and caterers to increase FV content in ready meals and takeaways, and to provide more meal options with fruit and vegetables in restaurants and other eating establishments. These are likely to benefit families who often eat in such settings. Smaller families with high parent-to-children ratios from more superior socio-economic backgrounds are in a better position to provide fruit and vegetables for their children. Although family size or composition cannot be intervened or changed, it is important for public health nutrition policy makers to target families of lower SES to reduce such diet inequality. Possible ways for intervention could be to subsidise the costs of fruit and vegetables for families in low socio-economic positions, as well as to concentrate efforts on families with low income-to-family size ratios.

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