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Exploring predictors of eating behaviour among adolescents by gender and socio-economic status

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Abstract

Objective: Guided by theory, this study explored cross-sectional differences in factors influencing adolescent eating behaviour including gender and socio-economic status (SES), and subsequently tested the longitudinal predictive power of the models.

Design/setting/subjects: Data were collected by questionnaires in a longitudinal study of adolescents (age 13 years at baseline) and their parents from Hordaland County, Norway. Association of personal and environmental variables (family, friends, school/society) with the consumption of fruit and vegetables (FV) and selected sources of fat and of sugar were assessed at age 15 ($n = 613$). The final cross-sectional models were subsequently employed in groups stratified by gender/SES and to predict consumption at age 21 ($n = 380$).

Results: The model explained more of the variation in the sugar score (21%) and the FV score (13.5%) than in the fat score (5%). SES was associated with both the sugar and FV scores. The strongest associations with the sugar score and FV were for antisocial behaviour and evaluation of own diet, respectively. The former association was significant in all gender/SES groups, whereas the latter association was only significant in the low SES groups. For all three types of food, the strongest significant predictors in the longitudinal models were frequency of consumption at age 15.

Conclusion: The model's ability to explain variation in eating behaviours differed by food type, and possibly by gender/SES, but previous eating behaviour was an important predictor for all three foods. Prospective studies should carefully operationalise theoretical constructs when further investigating the influences of and interrelationships between these factors and gender/SES on the development of eating behaviours.

Keywords
Adolescents
Eating behaviour
Gender
Socio-economic status
Theory
Longitudinal

Interventions aimed at establishing healthy eating behaviour at an early age are grounded in epidemiological evidence of the link between diet and chronic diseases, such as cancer and cardiovascular diseases (CVD). These interventions are based on theories concerning behaviour change[1,2], although most intervention studies have shown only weak to moderate effects on eating behaviour[3]. These discouraging results point to the need for performing analytical studies to investigate the potential mechanisms that mediate the connection between changes in personal and environmental factors and changes in eating behaviour[3,4]. To date, only a few analytical studies applying theory to investigate personal as well as environmental factors influencing adolescents' eating behaviours have been published[5–8], and only one longitudinal study has been identified[9].

Many potential predictors of eating behaviour have been suggested[5,10]. In Social Cognitive Theory (SCT), behaviour, personal factors and environmental factors are proposed to dynamically and reciprocally influence each other[11]. Behaviour includes both the intervention target and other behaviours that might co-vary with it. Eating behaviour has repeatedly been shown to cluster with other health-related behaviours[12–15]. Personal factors of the SCT include both cognitions and emotions, but the influence of general perceptions of oneself[16,17] has been given less attention than behaviour-specific self-efficacy[11]. When interventions are developed based on SCT the environmental influence has often been divided into family, peers and school/society to facilitate intervention by physical (e.g. availability) or social changes (e.g. modelling of behaviour) in multiple domains. In Problem Behaviour Theory (PBT)[18], there is an emphasis on the influence of both proximal and distal factors on the socialisation of adolescents into conventional behaviour. Although proximal variables (e.g. attitudes) may explain much of the variation in a health behaviour, distal variables (e.g. liking school) could contribute to understanding the underlying causes. Family, peers and school/society are important actors in this socialisation

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process, which, according to PBT, is aimed at maintaining conventional behaviour in a society. The balance between conventional and unconventional behaviour in the immediate environment surrounding the adolescent is therefore central in this theory.

Recently, the importance of addressing both gender and differences in socio-economic status (SES) in predictors of health within the same study has been stressed[19] in order to understand how inequality in health is formed. Within dietary research this is underscored by the repeated finding that women from higher social classes make healthier food choices than others[20]. Similarly, gender and SES differences in eating behaviours have been found among adolescents in Northern European countries, the USA and Australia[7,9,21–26].

Epidemiology has provided evidence that fruit and vegetables (FV) intake protects against CVD and certain cancers[27,28], whereas consumption of fat has been related to increased risk of CVD[29] as well as obesity and type 2 diabetes[30]. The epidemiological evidence of detrimental effects of high consumption of sugar is debated[31]. However, soft drinks displace more nutrient-dense drinks such as milk and fruit juice[32], and may result in over-consumption of energy leading to obesity[33]. From a behavioural change perspective, giving specific advice about the amount and type of food to eat is considered more effective than giving general recommendations to eat a healthy and varied diet[2].

Guided by the above theories, the aim of this paper is therefore to assess the importance of different influences on consumption of FV and selected sources of fat and sugar cross-sectionally in mid-adolescence, by investigating the association of these foods with proximal and distal factors by domains: the personal/behavioural domain and three environmental domains (family, peers, school/society). Furthermore, we explore differences in influencing factors by subgroups of the adolescents determined by gender and SES. Finally, we determine the longitudinal predictive power of the final models on the same eating behaviours in early adulthood while controlling for the eating behaviours in mid-adolescence.

Methods

Design and sample

The Norwegian Longitudinal Health Behaviour (NLHB) Study is a two-generation cohort study focusing on health behaviours. In 1990, 22 schools were randomly selected from all public schools in Hordaland County, Norway, and all of the 13-year-olds in these schools ($n = 1190$) and their parents were invited to participate. The response rate of the adolescents at baseline was 77.6% ($n = 924$), and of the fathers and mothers of these 924 adolescents it was 70.1% ($n = 648$) and 79.5% ($n = 735$), respectively. Of the 266 adolescents not participating, 222 parents/guardians did not provide written consent, 41 adolescents refused and three had incomplete forms at baseline. Participants and non-participants did not differ with respect to gender or urban/rural ratio[34]. At age 15 years, 866 of the 924 participated, of whom 613 had complete data for all of the variables included in these cross-sectional analyses. Furthermore, 380 of these participants had complete data for eating behaviours at age 21 years.

Procedure

Self-administered questionnaires were distributed through the schools at ages 13–15, and thereafter by mail both to the adolescents and their parents. Parents were surveyed when the adolescents were 13, 16 and 19 years old. All data collections were performed during the month of October. The study was approved by the Norwegian Data Inspectorate, and has been conducted in full accordance with ethical principles, including the provisions of the World Medical Association Declaration of Helsinki.

Instrument

Items from the well-established cross-national World Health Organization (WHO) study on Health Behaviour in School-aged Children (HBSC)[12,13,35] were used for several of the core questions on health/health behaviours in the survey instruments. In addition, both behaviour-specific proximal variables and general distal variables were included, using established scales when available[34,36–39].

Dependent variables

Consumption of FV was measured as the sum of the responses to two frequency questions about fruit and vegetables over the last 3 months[13]. Response categories were (re-coded to times per week): more than once a day (10), once a day (7), 3–6 times per week (4.5), 1–2 times a week (1.5), seldom/never (0.5). The one-week test–retest reliability in 80 of the participants at age 14 was $r = 0.70$ (Pearson correlation); a recent reliability study among 17–19-year-olds ($n = 156$) reported $r = 0.81$ for the same score[40]. The fat score at age 15 was the sum of three frequency questions on the consumption of full-fat milk, butter and margarine as spreads with the same response categories as for FV and a test–retest reliability of $r = 0.69$. The fat score at age 21 was based on the validated short version[41] of an extensive food-frequency questionnaire used for surveillance in Norway[42], which at age 19 had replaced most of the HBSC questions on foods previously included in the survey instrument. Those who reported that they did not use spread on bread were assigned the value zero, whereas, for those who used spread, the number of slices of bread per day was used: do not use (0), less than once per day (0.5), 1–2 per day (1.5), 3–4 per day (3.5), 5–6 per day (5.5), 7–8 per day (7.5), 9–10 per day (9.5), 11 or more (12). This was added to the responses on consumption of glasses of full-fat milk, which was measured with the same response categories,

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to form a score on consumption of selected sources of fat per day. Consumption of selected sugary foods was measured by adding the responses to two frequency questions about sweets/chocolate and soft drinks with sugar. Response categories for soft drinks were as for FV, whereas those for sweets/chocolate were: once a day (7), 3–6 times per week (4.5), 1–2 times a week (1.5), seldom (0.5), never (0). Test–retest reliability of this score at age 14 was $r = 0.85$, and $r = 0.87$ in the study of 17–19-year-olds[40].

Independent variables

Demographics

Preliminary analyses indicated that an SES measure based on parents' occupation was not significantly correlated to the eating behaviours, whereas parental education was significantly correlated. The educational variable was based on parental self-reports supplemented with the child's answer if the parent's answer was missing. If at least one of the parents had completed college or university, the variable was coded one (else 0). Kappa statistics between parent and child reports for such dichotomous variables were 0.55 and 0.43 for the fathers and mothers, respectively, higher than for the four-level measure previously described[43].

Personal

Behavioural variables included were physical activity, smoking, dieting, use of dietary supplements and number of meals eaten per week. Physical activity was assessed by a frequency question about out-of-school exercise that caused breathlessness or sweating, and had seven response categories ranging from never to every day, re-coded to times per week. Smokers reported smoking daily, weekly, or less often than weekly. Dieters had dieted at least once during the last 12 months. Users of dietary supplements reported taking either vitamins, iron or cod liver oil at least weekly. Frequency of consumption of breakfast, lunch, dinner and a smaller late evening meal, each with four response categories ranging from never/rarely to every day, was re-coded to times per week and added to form a meal score.

Cognitions about health or self were assessed by the following items. Evaluation of health compared with others of the same age was collapsed from five to three groups, based on the distribution of responses: much worse/worse/neither better nor worse, good and very good. Similarly, evaluation of diet compared with others of the same age was collapsed from five to three groups: much worse/worse, neither better nor worse and better/much better. The global negative self-evaluation scale[37] (six items, Cronbach's alpha = 0.90) included statements such as '*I would like to change many things about myself*' and '*I feel I do not have much to be proud of*', and had six response categories (applies exactly to does not apply at all). The subjective health complaints scale[35] (eight items, Cronbach's alpha = 0.69) assessed frequencies (very often, sometimes, seldom or never) of minor health problems (i.e. headache, stomach ache, lack of appetite, lack of energy). If the participant had more than one missing response on the scale in question, his/her score was calculated as the mean of the available responses.

Family

Modelling of health-related behaviours by parents was operationalised through physical activity and smoking. If one or both of the parents were perceived by the adolescent to be physically active 2–3 times per week or more, the variable was coded one (else 0). Perceived parental smoking daily or sometimes was coded 1 (else 0). The adolescent's perception of how the parents evaluated his/her diet was collapsed from five to three groups: very bad/bad, okay and good/very good. Relationships with the parents were based on two scales[38], 'Positive relations' (seven items, Cronbach's alpha = 0.84) and 'Parental monitoring' (six items, Cronbach's alpha = 0.81), with response categories as for the negative self-evaluation scale and a maximum of one missing response allowed on each scale. Representative examples of items used for each of the scales are, respectively: '*I enjoy myself when I am together with my parents*' and '*It is important for my parents to know where I am and what I do during my leisure time*'.

Friends

The reported frequency of physical activity and smoking of the best friend were coded as for the adolescents themselves. A scale on relationship with peers[39] (10 items, Cronbach's alpha = 0.92) with response scale as for negative self-evaluation included statements such as: '*Other kids my age seem to enjoy being with me*' or '*If I had to move to a new school, I feel I would soon make new friends*'. Responses to a minimum of seven items were required to calculate the score.

School/society

Two single questions from the HBSC study[12] addressed how the adolescent currently liked school and how he/she perceived the teacher's evaluation of his/her academic performance compared with others in the class. The response categories to the former question were: very much, quite a lot, not so much and not at all; and to the latter question: very good, good, average and below average. A scale with six items (Cronbach's alpha = 0.64) with four response categories ranging from never to several times since the summer vacation tapped information about antisocial behaviour like '*Having had a fierce quarrel with a teacher*' and '*Deliberately damage seats in a bus, a movie theatre or other places*'. Responses

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to a minimum of five items were required to calculate the score.

Statistical analyses

All analyses were performed using SAS version 8.1. One-way analyses of variance (ANOVA) and chi-square statistics were used to compare those at each stage of analysis with those who dropped out.

Two-way analyses of variation for unbalanced designs (PROC GLM) were used to test for main effects and interaction effects of gender and SES when describing the means and prevalences of the variables. Pearson correlation between the dependent variables at ages 15 and 21 assessed stability within and independence between the eating behaviours.

Preliminary linear regression analyses (PROC REG) of each dependent variable on each independent variable, and all possible two-way interactions between that variable and gender and SES, were performed. These series of analyses showed that there were significant interactions ($P < 0.05$) for the independent variable and gender ($n = 5$ interactions), the independent variable and SES ($n = 8$), and gender and SES ($n = 1$) (results not shown). For $P < 0.20$ the numbers increased to 11, 20 and 14, respectively, representing 25% (45/180) of the possible interactions. The stratification by gender and SES, although theory-based, was thus not strongly supported. Therefore, gender and SES were included as variables in the models, and only the final cross-domain models at age 15 years were analysed separately for low SES boys, high SES boys, low SES girls and high SES girls.

Independent variables with bivariate Pearson correlations with a dependent variable with $P \leq 0.05$ were included in the stepwise linear regression analyses (PROC REG) of the within-domain models (personal, family, friends, school/society). Figure 1 shows an overview of all possible variables in the model. The same inclusion criteria were used to enter variables from the within-domain models into the analyses of the cross-domain models. All of the significant variables in the cross-domain models were included in the longitudinal models.

Results

Attrition

Comparing those with complete data ($n = 613$) with those with missing data ($n = 253$) at age 15, and those with complete data at ages 15 and 21 ($n = 380$) with those who dropped out between the ages of 15 and 21 ($n = 233$), revealed no differences in consumption of FV or sugar score, in physical activity or in smoking between the groups (Table 1). Both types of attrition were more common among boys than among girls. Those who had complete data at age 15 had a lower fat score and reported more positive relations with their parents than those with missing data, and those who remained in the study at age

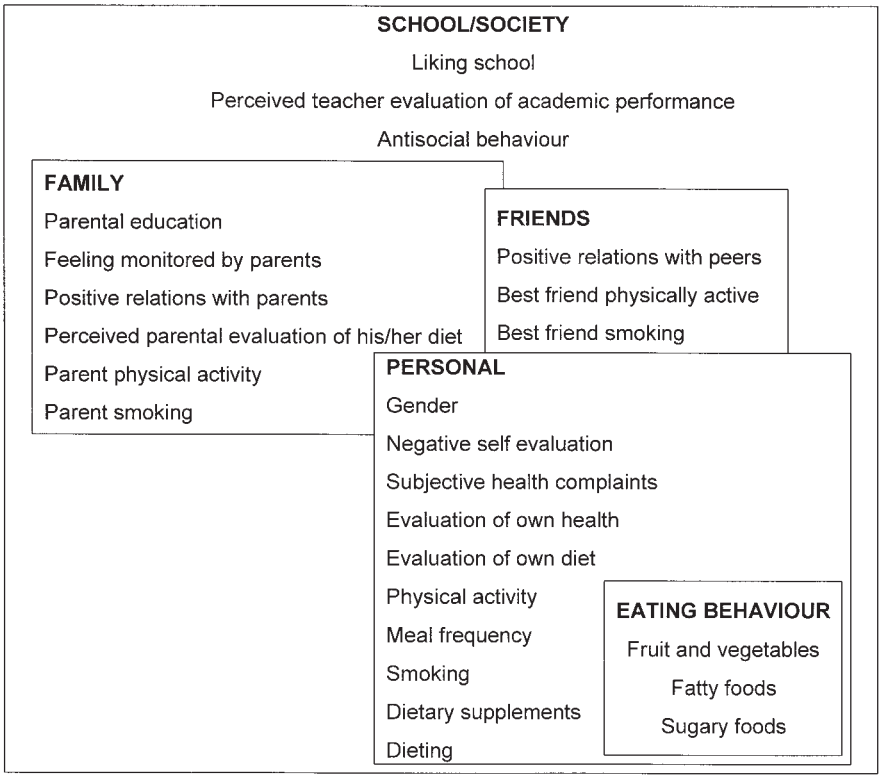

Fig. 1 A model of psychosocial domains that may influence adolescent eating behaviour, derived from the perspectives of Social Cognitive Theory and Problem Behaviour Theory. Domain names are given in capital letters. The variables used in this study to operationalise each domain are also given.

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Table 1 Attrition analyses for selected behaviours/characteristics at age 15 comparing those with complete data at age 15 with those with incomplete data at age 15, and comparing those with data at age 21 with those who dropped out between ages 15 and 21 on variables at age 15

	Participants		Drop-outs		ANOVA/Chi-square	
Variable	*n*	Mean	*n*	Mean	*F*-value/χ^2	*P*
Attrition due to missing answers at age 15						
Gender (% girls)	613	47	309	40	3.72	0.05
Education (% at least one parent with a college/university degree)	613	44	210	37	2.78	0.1
Fruit/vegetables (times/week)	613	10.4	236	10.4	0.05	0.8
Full-fat milk/spreads (times/week)	613	8.1	202	9.6	8.63	0.003
Soft drinks/sweets (times/week)	613	5.0	236	5.2	0.61	0.4
Physical activity (times/week)	613	3.0	236	2.9	1.24	0.3
Smoking (% smokers)	613	33	211	38	2.32	0.1
Positive relations with parents (mean score)	613	3.2	190	3.0	6.89	0.009
Antisocial behaviour (mean score)	613	1.4	197	1.4	1.10	0.3
Attrition between age 15 and age 21						
Gender (% girls)	380	54	233	36	20.03	<0.001
Education (% at least one parent with a college/university degree)	380	49	233	36	10.02	0.002
Fruit/vegetables (times/week)	380	10.5	233	10.1	1.05	0.3
Full-fat milk/spreads (times/week)	380	8.2	233	8.0	0.17	0.7
Soft drinks/sweets (times/week)	380	4.9	233	5.3	2.77	0.1
Physical activity (times/week)	380	3.0	233	3.2	1.47	0.2
Smoking (% smokers)	380	31	233	35	1.13	0.3
Positive relations with parents (mean score)	380	3.2	233	3.2	0.55	0.5
Antisocial behaviour (mean score)	380	1.4	233	1.5	5.14	0.02

21 had less antisocial behaviour at age 15 than those who dropped out. Parental education was not related to incomplete data at age 15, but more participants with at least one higher educated parent remained in the study between the ages 15 and 21 than dropped out of the study. Smoking was more common among those with incomplete data at either age 15 or age 21, although neither difference reached statistical significance.

Dependent variables

Table 2 shows that boys had higher fat and sugar scores than girls at age 15, and high SES adolescents had higher

Table 2 Means (times/week), standard deviation (SD) and bivariate correlations for the frequency of consumption of fruit and vegetables (FV), fat (F) and sweets/chocolate/soft drinks (S) at ages 15 and 21 in a sample of boys and girls of low and high socio-economic status (SES)

	Boys											
	Low SES ($n = 186/87$†)						High SES ($n = 138/87$†)					
	FV15	FV21	F15	F21‡	S15	S21	FV15	FV21	F15	F21‡	S15	S21
Mean‡	9.5[b]	5.6[a,b]	8.8[a]	4.6[a]	5.9[a,b]	6.0[a,b]	11.7	8.4	9.1	4.5	5.2	5.6
SD	5.1	4.5	6.7	3.6	3.6	3.3	4.9	4.7	6.1	3.3	3.5	3.3
1. FV15	1						1					
2. FV21	0.33**	1					0.34***	1				
3. F15	0.16*	0.11	1				0.05	−0.01	1			
4. F21§	0.04	0.04	0.19	1			−0.02	−0.12	0.34**	1		
5. S15	0.01	0.02	0.25***	−0.09	1		0.15	−0.06	0.01	0.03	1	
6. S21	0.03	0.00	0.10	−0.09	0.74***	1	0.17	0.14	0.11	−0.14	0.73***	1
	Girls											
	Low SES ($n = 159/107$†)						High SES ($n = 130/98$†)					
	FV15	FV21	F15	F21‡	S15	S21	FV15	FV21	F15	F21‡	S15	S21
Mean	9.8	7.9	6.8	3.3	4.8	5.0	10.9	8.8	7.6	2.7	3.9	4.2
SD	5.0	4.8	5.5	2.8	3.1	3.0	5.1	5.0	5.8	2.5	2.1	2.4
1. FV15	1						1					
2. FV21	0.51***	1					0.44***	1				
3. F15	0.03	0.03	1				0.07	0.11	1			
4. F21§	0.09	−0.05	0.26**	1			−0.02	−0.17	0.37***	1		
5. S15	−0.06	−0.12	0.09	−0.07	1		−0.09	0.08	0.03	−0.05	1	
6. S21	−0.03	−0.16	0.06	0.02	0.75***	1	−0.01	0.09	0.01	0.02	0.48***	

† Number of participants at age 15/at ages 15 and 21.
‡ [a]Gender differences in mean for that food, [b]SES differences in mean for that food ($P < 0.05$).
§ Measured in times/day.
*, $P \leq 0.05$; **, $P \leq 0.01$; ***, $P \leq 0.001$ for the significance of the correlations.

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FV and lower sugar scores than low SES adolescents at both ages. The FV score at age 21 was lower in low SES boys than in low SES girls, but not different in high SES groups. Consumption of FV at ages 15 and 21 was correlated, as were the sugar scores. Correlations across ages 15 and 21 were weaker for the fat score, particularly among the low SES boys, where the fat score at age 15 was not significantly correlated with fat score at age 21, whereas it was correlated to the two other eating behaviours at age 15.

Independent variables

The mean levels of the independent variables in each of the groups are shown in Table 3. There was a high prevalence of smoking (about one-third) and of dieting among the girls (about one-half). On average the adolescents tended to rate their self-evaluation, subjective health complaints and relations with family and peers as positive, and their overall diet as good. However, the low SES girls differed in a negative way from the other three groups in several aspects: more negative self-evaluation, less positive relations with parents, higher prevalence of smoking themselves, at least one smoking parent, and best friend smoking. They also had the lowest mean meal frequency, the least positive relations with peers, and the lowest frequency of physical activity. High SES boys differed from the other groups by having the least negative self-evaluations, the highest frequency of physical activity and meals per week, and the lowest proportion of at least one smoking parent. Significant ($P < 0.05$) differences between boys and girls and between high and low SES were found for most of the independent variables, whereas significant gender × SES interactions were only found for feeling monitored by parents and smoking.

Associations with behaviour at age 15 and prediction of behaviour at age 21

Few bivariate correlations between the fat score and the independent variables had $P \leq 0.05$. The two significant variables, meals (positively associated) and dieting (negatively associated), explained only $R^2 = 4.8\%$ ($R^2_{adj} = 4.2\%$) of the variation in the cross-domain model at age 15 years. There was a tendency that the boys had higher scores than girls ($P = 0.09$). The significant predictors ($P < 0.05$) of the fat score at age 21 ($R^2 = 14.6\%$, $R^2_{adj} = 13.3\%$) were previous consumption and gender (boys had higher scores, $P = 0.003$), whereas SES (low SES had higher scores, $P = 0.1$) and meals were approaching significance (positively associated, $P = 0.07$). These models are not further presented in the tables. For consumption of FV and the sugar score, Tables 4 and 5 show the bivariate correlations, the within-domain

Table 3 Descriptives (means and standard deviations (SD)) of independent variables for boys and girls of low and high socio-economic status (SES) at age 15*

	Boys				Girls					
	Low SES ($n = 186$)		High SES ($n = 138$)		Low SES ($n = 159$)		High SES ($n = 130$)		Possible range†	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Low	High
Personal										
Negative self-evaluation (scale)[a,b]	1.4	1.0	1.1	0.9	2.2	1.3	1.9	1.2	0	5
Subjective health complaints (scale)[a]	0.3	0.3	0.4	0.3	0.6	0.3	0.5	0.3	0	2
Evaluation of own health (3 categories)[a]	2.0	0.7	2.1	0.7	1.8	0.7	1.9	0.7	1	3
Evaluation of own diet (3 categories)[a,b]	2.1	0.5	2.3	0.5	2.0	0.5	2.2	0.5	1	3
Physical activity (times/week)[a,b]	3.2	2.2	3.8	2.2	2.4	1.8	2.8	1.9	0	7
Meal frequency (times/week)[a,b]	24.6	4.2	26.1	2.8	21.9	5.3	23.4	4.6	2	28
Smoking (%)[c]	29		29		43		28		0	1
Use dietary supplements at least weekly (%)[a]	32		36		44		53		0	1
Dieting within last 12 months (%)[a]	16		8		46		43		0	1
Family										
Feeling monitored by parents (scale)[c]	3.8	0.8	3.7	0.9	3.6	1.0	3.8	0.8	0	5
Positive relations with parents (scale)[a,b]	3.3	0.9	3.3	0.7	2.9	1.0	3.2	0.9	0	5
Perceived parental evaluation of his/her diet (3 categories)[a,b]	2.2	0.7	2.3	0.6	2.1	0.7	2.2	0.6	1	3
Physical activity (at least one parent ≥2–3 times/week, %)[a,b]	34		49		45		58		0	1
Smoking (at least one parent smokes, %)[a,b]	65		43		73		57		0	1
Friends										
Positive relations with peers (scale)[a,b]	3.2	0.9	3.3	0.9	3.0	0.9	3.2	0.8	0	5
Best friend physically active (times/week)[a]	2.5	1.7	2.8	1.6	2.3	1.6	2.3	1.5	0	5
Best friend smoking (%)[b]	34		25		38		30		0	1
School/society										
Liking school (4 categories)[a,b]	2.9	0.7	3.1	0.7	3.1	0.7	3.2	0.6	1	4
Perceived teacher evaluation of academic performance (4 categories)[b]	2.4	0.7	2.8	0.7	2.4	0.6	2.8	0.6	1	4
Antisocial behaviour (scale)[a]	1.5	0.4	1.5	0.5	1.4	0.4	1.3	0.4	1	4

*Significant differences ($P \leq 0.05$) in means/prevalences by: [a]gender, [b]SES and [c]gender/SES interactions.
† High values are more positive evaluations/higher frequencies, thus higher scores on negative self-evaluation, subjective health complaints and antisocial behaviour indicate adolescents with more problems.

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models (including gender and SES in each model), the cross-domain models and the predictive models, the latter controlling for previous eating behaviour. In the cross-domain models, consumption of FV was positively associated with evaluation of own diet, physical activity, meal frequency and relations with parents and friends (Table 4), whereas the sugar score was positively associated with antisocial behaviour and negatively associated with dieting, perceived parental evaluation of diet and liking school (Table 5). Only previous consumption was a significant predictor of the sugar score at age 21 (Table 5), whereas evaluation of own diet, positive relations with parents and gender contributed in addition to previous consumption in predicting consumption of FV at age 21 (Table 4). In the latter model, SES also approached significance. Table 6 indicates that some of these relationships appear to vary by gender/SES groups.

Discussion

There are three main findings in this study. Firstly, factors associated with the FV – evaluation of own diet, physical activity, meal frequency and relations with parents and friends – differed from those associated with the sugar score – antisocial behaviour, dieting, perceived parental evaluation of diet and liking school. Also, the only factors associated with the fat score were meals and dieting. Secondly, there were differences in both the dependent and the independent variables by gender and SES. Yet there were SES and gender effects

Table 4 Linear regression models assessing the association of personal and environmental factors with consumption of fruit and vegetables at age 15, and testing the cross-domain models' ability to predict the frequency of consumption at age 21 while controlling for frequency of consumption at age 15. Bivariate correlations (r) with $P \leq 0.05$, regression coefficients (b) and standardised regression coefficients (β)

	Bivariate correlations		Multivariate models within domain, age 15			Multivariate model across domains, age 15			Multivariate model predictive, ages 15/21		
Variable	r	P	b	β	P	b	β	P	b	β	P
Personal											
Negative self-evaluation	−0.11	0.005									
Evaluation of own health	0.20	<0.001	0.90	0.12	0.004						
Evaluation of own diet	0.24	<0.001	1.56	0.16	<0.001	1.58	0.16	<0.001	1.01	0.10	0.04
Physical activity	0.17	<0.001	0.25	0.10	0.01	0.30	0.13	0.001	0.02	0.01	0.9
Meal frequency	0.21	<0.001	0.13	0.12	0.006	0.12	0.11	0.01	0.00	0.00	1.0
Use dietary supplements weekly	0.11	0.005	0.78	0.08	0.05						
Gender (0 = boys, 1 = girls)	−0.01	0.8	0.71	0.07	0.09	0.90	0.09	0.03	1.78	0.18	<0.001
SES (0 = low, 1 = high)	0.16	<0.001	1.02	0.10	0.01	0.91	0.09	0.03	0.87	0.09	0.06
			$R^2 = 12.7\%$ ($R^2_{adj} = 11.7\%$)								
Family											
Feeling monitored by parents	0.09	0.02									
Positive relations with parents	0.20	<0.001	0.78	0.14	<0.001	0.55	0.10	0.02	0.74	0.13	0.009
Perceived parents' evaluation of his/her diet	0.21	<0.001	1.21	0.16	<0.001						
Parents physically active	0.12	0.004									
Parents smoking	−0.09	0.03									
Gender (0 = boys, 1 = girls)	−0.01	0.8	0.22	0.02	0.6						
SES (0 = low, 1 = high)	0.16	<0.001	1.39	0.14	0.001						
			$R^2 = 8.2\%$ ($R^2_{adj} = 7.6\%$)								
Friends											
Positive relations with peers	0.19	<0.001	1.07	0.19	<0.001	0.61	0.11	0.009	−0.36	−0.06	0.2
Best friend smoking	−0.10	0.01	−1.05	−0.10	0.02						
Gender (0 = boys, 1 = girls)	−0.01	0.8	0.10	0.01	0.8						
SES (0 = low, 1 = high)	0.16	<0.001	1.45	0.14	<0.001						
			$R^2 = 6.8\%$ ($R^2_{adj} = 6.2\%$)								
School/society											
Likes school	0.14	0.004	0.67	0.09	0.03						
Perceived teacher evaluation of academic performance	0.21	<0.001	1.08	0.15	<0.001						
Gender (0 = boys, 1 = girls)	−0.01	0.8	−0.22	−0.02	0.6						
SES (0 = low, 1 = high)	0.16	<0.001	1.13	0.11	0.008						
			$R^2 = 6.2\%$ ($R^2_{adj} = 5.5\%$)								
						$R^2 = 13.5\%$ ($R^2_{adj} = 12.5\%$)					
Fruit and vegetables intake at age 15									0.37	0.38	<0.001
									$R^2 = 24.4\%$ ($R^2_{adj} = 22.8\%$)		

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Table 5 Linear regression models assessing the association of personal and environmental factors with consumption of sweet/chocolates and soft drinks (with sugar) at age 15, and testing the cross-domain models' ability to predict the frequency of consumption at age 21 while controlling for frequency of consumption at age 15. Bivariate correlations (r) with $P \leq 0.05$, regression coefficients (b) and standardised regression coefficients (β)

	Bivariate correlations		Multivariate models within domain, age 15			Multivariate model across domains, age 15			Multivariate model predictive, ages 15/21		
Variable	r	P	b	β	P	b	β	P	b	β	P
Personal											
Evaluation of own diet	−0.11	0.007	−0.65	−0.10	0.01						
Smoking	0.19	<0.001	1.36	0.20	<0.001						
Use dietary supplements weekly	−0.09	0.02									
Dieting	−0.12	0.003	−0.72	−0.10	0.02	−0.87	−0.12	0.002	0.16	0.02	0.5
Gender (0 = boys, 1 = girls)	−0.19	<0.001	−1.13	−0.17	<0.001	−0.61	−0.09	0.02	−0.34	−0.06	0.2
SES (0 = low, 1 = high)	−0.12	0.003	−0.60	−0.09	0.02	−0.65	−0.10	0.006	−0.26	−0.04	0.2
			$R^2 = 10.4\%$ ($R^2_{adj} = 9.7\%$)								
Family											
Feeling monitored by parents	−0.12	0.003	−0.35	−0.10	0.01						
Positive relations with parents	−0.08	0.04									
Perceived parents' evaluation of his/her diet	−0.17	<0.001	−0.79	−0.16	<0.001	−0.41	−0.08	0.03	−0.05	−0.01	0.8
Gender (0 = boys, 1 = girls)	−0.19	<0.001	−1.28	−0.10	<0.001						
SES (0 = low, 1 = high)	−0.12	0.003	−0.65	−0.10	0.01						
			$R^2 = 8.9\%$ ($R^2_{adj} = 8.3\%$)								
Friends											
Best friend smoking	0.21	<0.001	1.43	0.21	<0.001						
Gender (0 = boys, 1 = girls)	−0.19	<0.001	−1.25	−0.19	<0.001						
SES (0 = low, 1 = high)	−0.12	0.003	−0.64	−0.10	0.01						
			$R^2 = 9.1\%$ ($R^2_{adj} = 8.6\%$)								
School/society											
Likes school	−0.23	<0.001	−0.60	−0.13	0.001	−0.56	−0.12	0.002	0.25	0.05	0.2
Perceived teacher evaluation of academic performance	−0.18	<0.001									
Antisocial behaviour	0.38	<0.001	2.63	0.34	<0.001	2.56	0.33	<0.001	0.06	0.01	0.8
Gender (0 = boys, 1 = girls)	−0.19	<0.001	−0.84	−0.13	<0.001						
SES (0 = low, 1 = high)	−0.12	0.003	−0.65	−0.09	0.007						
			$R^2 = 19.5\%$ ($R^2_{adj} = 18.9\%$)								
						$R^2 = 21.2\%$ ($R^2_{adj} = 20.4\%$)					
Sweets/chocolate and soft drinks intake at age 15									0.70	0.71	<0.001
									$R^2 = 51.9\%$ ($R^2_{adj} = 51.0\%$)		

on the sugar score, and SES effects only on the FV score in the within- and cross-domain models. However, the significant variables in the cross-domain models for FV and the sugar score analysed by gender/SES groups appeared to differ by these groups. Thirdly, there was a strong prospective influence of consumption at age 15 on consumption at age 21.

The cross-domain models explained respectively 21%, 13.5% and 5% of the variation in the sugar score, FV and the fat score. Yet the sum of the explained variation in FV and the sugar score based on the within-domain models was 34% and 38%, respectively. The discrepancy between these sums and the explained variations in the cross-domain models indicates that there was some overlap in the variables' ability to explain variation in the food intakes. Own smoking, best friends smoking and antisocial behaviour are examples of such variables for the sugar score. Others have also found that unhealthy eating is associated with other health-compromising behaviours[12–15], as well as evenings with friends[12]. Parental smoking, on the other hand, was not associated with the sugar score despite the fact that parents' and child's smoking habits have been found to be associated[36]. Thus, sugary foods could have a symbolic function among these adolescents, or they are simply the only foods available at places where these youth gather, but this needs further investigation. The association between FV and other health-enhancing behaviours also supports the findings of others[12,13,25,44], but parents' or friends' physical activity was not strongly associated with FV. The social environmental influence through modelling of other health-enhancing behaviours may thus be less important than individual choices, behaviour-specific modelling or other environmental factors. Examples of other environmental factors are positive relations with family and friends, liking school and perceived positive evaluation of

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Table 6 The cross-domain models' ability to explain variation in frequency of consumption of fruit/vegetables and of sweets/chocolate/soft drinks with sugar by gender and socio-economic status (SES) groups

	Low SES boys ($n = 186$)			High SES boys ($n = 138$)			Low SES girls ($n = 159$)			High SES girls ($n = 130$)		
	b	*β*	*P*	*b*	*β*	*P*	*b*	*β*	*P*	*b*	*β*	*P*
Fruit/vegetables*												
Evaluation of own diet	2.19	0.22	0.003	0.79	0.09	0.3	2.47	0.23	0.007	1.01	0.10	0.3
Physical activity	0.40	0.17	0.02	0.37	0.17	0.04	−0.03	−0.01	0.9	0.29	0.11	0.2
Meal frequency	0.07	0.06	0.4	0.14	0.08	0.4	0.08	0.09	0.3	0.15	0.13	0.1
Positive relations with parents	0.52	0.09	0.2	0.49	0.07	0.4	1.02	0.21	0.008	0.05	0.01	0.9
Positive relations with peers	0.35	0.06	0.4	1.32	0.24	0.008	0.53	0.09	0.2	0.58	0.10	0.3
	$R^2 = 12.2\%$ ($R^2_{adj} = 9.8\%$)			$R^2 = 14.8\%$ ($R^2_{adj} = 11.6\%$)			$R^2 = 17.2\%$ ($R^2_{adj} = 14.5\%$)			$R^2 = 7.2\%$ ($R^2_{adj} = 3.5\%$)		
Sweets/chocolate/soft drinks with sugar												
Dieting	−1.17	−0.12	0.1	−0.88	−0.07	0.4	−1.39	−0.22	0.002	0.03	0.01	0.9
Perceived parents' evaluation of his/her diet	−0.45	−0.08	0.2	−0.18	−0.03	0.7	−0.40	−0.09	0.2	−0.83	−0.25	0.007
Likes school	−0.97	−0.20	0.005	−0.24	−0.05	0.6	−0.62	−0.14	0.07	0.34	0.09	0.3
Antisocial behaviour	2.12	0.24	0.001	3.82	0.51	<0.001	2.97	0.38	<0.001	0.99	0.18	0.05
	$R^2 = 12.3\%$ ($R^2_{adj} = 10.4\%$)			$R^2 = 27.8\%$ ($R^2_{adj} = 25.6\%$)			$R^2 = 27.8\%$ ($R^2_{adj} = 25.9\%$)			$R^2 = 10.2\%$ ($R^2_{adj} = 7.3\%$)		

*The high SES girls' model is not significant ($F = 1.93$, $P = 0.09$).

academic performance by the teacher, which were all positively associated with FV in the within-domain models. Good relations with family, friends and school would influence the acceptance of the behaviours promoted or modelled by these actors in the socialisation process. There is, however, an ambiguity in these independent variables because good relations can promote both health-enhancing behaviours (i.e. physically active friends) and health-compromising behaviours (i.e. smoking parents). Yet our findings support those of others who have found that family connectedness[25] or easy communication with parents is positively associated with healthy eating habits[12]. In a PBT perspective[18], the association between good relations with parents and FV could be interpreted as socialisation into conventional behaviour, whereas the association between the sugar score and antisocial behaviour/smoking would be socialisation into unconventional behaviour. The stronger negative association with perceived parental evaluation of diet than with own evaluation of diet indicates that the adolescents are aware of the conventional norm, but may not have accepted it as their own. For FV, it appears that they have internalised the norms because own evaluation of diet is in the cross-domain model whereas perceived parental evaluation is not. Other researchers have grouped adolescents taking into consideration their relations across the domains of family, friends and school, and found that these underlying personality types were related to health behaviours[17,45]. In order to provide intervention messages that can reach these different types of adolescents, their food environment and the symbolic meaning of foods in these groups need to be investigated. This may also imply that intervention settings other than the school and family need to be considered.

The amount of variation explained in the fat score was low. Adding only the use of full-fat milk and butter as indicators of consumption of saturated fat did not improve the results (data not shown). Part of the explanation may be that these foods were not representative of the adolescents' fat consumption, as for instance chips/crisps and cheese were not included. The survey was made in the late 1980s when milk and spreads were the focus of nutrition campaigns aimed at lowering the population's mean energy intake from fat. Considering the age of the participants, the effect of these campaigns on their eating behaviours are most likely to be indirect through their parents' food choices. It was therefore interesting to investigate these foods in this model that included other parental health behaviours and parental SES. Another part of the explanation for the low amount of variation explained may be that proximal variables not included in the survey are more important influences: i.e. attitudes and self-efficacy have been shown to be associated with consumption of fat[7,8].

There were effects of gender and SES in both the within- and cross-domain models for the sugar score and of SES for FV. Boys and low SES adolescents had higher sugar scores than girls and high SES adolescents, and high SES adolescents reported eating FV more often than low SES adolescents. In the cross-domain model for FV, a gender effect was found indicating that girls ate FV more frequently, but this was not found in any of the within-domain models. In the longitudinal model, however, this effect was clear, which supports the previously reported tendency towards an increasing gender difference of this behaviour during adolescence[46]. Thus, it appears that gender and SES might be important to consider when choosing messages and channels in interventions aimed at establishing healthy eating behaviours. When the cross-domain models for FV and the sugar score were analysed separately by gender/SES, a maximum of two of the four or five variables in the models were significant in any of

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the groups. The positive association between evaluation of own diet and FV appeared to be more important among low SES than high SES adolescents, whereas the negative association between perceived parental evaluation of diet and the sugar score was only significant among the high SES girls. The high SES girls also differed from the other groups because the FV model was not significant, and antisocial behaviour was not as strongly associated with the sugar score as in the other groups. Furthermore, positive relations with parents and FV were only associated in the low SES girls' model, and positive relations with peers were only associated with FV in the high SES boys' model. The variations in the strength of associations were not tested statistically for significant differences between the groups, and could thus be variations around the same population mean associations. However, if the differences are real, they indicate that interventions applying self-evaluation of diet may be more effective among low SES adolescents, but also that school as an arena may not be as effective for changing the consumption of sugary foods among low SES adolescents.

The strong influence of consumption at age 15 on consumption at age 21 supports the findings by others that eating habits are already established by mid-adolescence[9]. However, stability of the consumption of FV was lower than for sugary foods, and other factors such as evaluation of own diet and positive relations with parents also contributed to the longitudinal model for FV. This indicates that stability in food consumption during adolescence may be influenced by different factors depending on the food and age period in question. The stability of sugary foods was lower for high SES girls than for the others, thus stability of eating behaviours may also be related to SES.

Before concluding, some methodological weaknesses should be addressed. High attrition was found due to both missing items at age 15 and dropout between ages 15 and 21. However, bivariate correlations calculated on all available data at age 15 showed similar patterns to the ones reported here (data not shown). It is possible that those with more stable habits remained in the study making the influence of eating behaviours at age 15 appear more important in the longitudinal analyses than they actually are, but the general changes in the eating behaviours do not suggest that this is a large problem. The consumption of the foods used to create the dependent measures was assessed by a limited number of questions and was based on frequency rather than amount. However, the reliability of the measures was good and such indicator questions are frequently used in surveillance studies[12,13,47]. Researchers investigating adolescent eating behaviours have used different measures of SES ranging from the traditional occupation of head of household or education[22,23] to geographical indices[21,26]. In this study, SES was assessed as parental education only. Compared with other measures such as current job or household income, parental education may be seen as a consistent influence throughout childhood and adolescence because most parents attain their education before they have children. The relatively low amount of variation explained may primarily be related to the inherent weakness of self-reported epidemiological measures. Behaviours, interpersonal relations, etc. are difficult for participants to characterise, partly because they change over time and partly because of ambiguities in the concepts addressed. Other factors such as unwillingness of the participant to be truthful or misunderstanding of the questions also contributes random noise to the dependent and independent variables. Within-person variation introduced by these ambiguities tends to attenuate relationships: they are estimated to be weaker than they really are.

In conclusion, the results demonstrate the complexity of assessing adolescent eating behaviour based on theoretical perspectives including environmental influences. One explanation for this may be that although the environmental influences vary by domain, the person is the same in all the domains and the effects of the domains may thus not be additive. However, the results also indicate that interventions in different domains may vary in effectiveness depending on the food and the gender/SES group in question, and this should be further explored. Finally, adolescents' eating behaviours appeared largely to have been established by mid-adolescence, which points to the importance of performing similar analyses in younger age groups. Future research should include theory-based qualitative studies to develop distal measures of environmental influences and proximal measures of salient belief structures in the target group. Moreover, carefully designed prospective studies applying these measures within a specified model are called for in order to guide prevention efforts aimed at a healthy development of eating behaviours from adolescence to adulthood.

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