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Ethnicity and SES are related to dietary patterns at age 5 in the Amsterdam Born Children and their Development (ABCD) cohort --Manuscript Draft--

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Abstract:	<p>Background: Health inequalities are already present at young age and tend to vary with ethnicity and socioeconomic status (SES). Diet is a major determinant of overweight, and studying dietary patterns as a whole in relation to overweight rather than single nutrients or foods has been suggested. We derived dietary patterns at age 5 and determined whether ethnicity and SES were both related to these dietary patterns.</p> <p>Methods: We analysed 2 769 validated Food Frequency Questionnaires filled in by mothers of children (5.7±0.5y) in the Amsterdam Born Children and their Development (ABCD) cohort. Food items were reduced to 41 food groups. Energy adjusted intake per food group (g/d) was used to derive dietary patterns using Principal Component Analysis and children were given a pattern score for each dietary pattern. We defined 5 ethnic groups (Dutch, Surinamese, Turkish, Moroccan, other ethnicities) and 3 SES groups (low, middle, high, based on maternal education). Multivariate ANOVA, with adjustment for age, gender and maternal age, was used to test potential associations between ethnicity or SES and dietary pattern scores. Post-hoc analyses with Bonferoni adjustment were used to examine differences between groups.</p> <p>Results: Principal Component Analysis identified 4 dietary patterns: a snacking, full-fat, meat and healthy dietary pattern, explaining 21% of the variation in dietary intake. Ethnicity was related to the dietary pattern scores ($p < 0.01$): non-Dutch children scored high on snacking and healthy pattern, whereas Turkish children scored high on full-fat and Surinamese children on the meat pattern. SES was related to the snacking, full-fat and meat patterns ($p < 0.01$): low SES children scored high on the snacking and meat pattern and low on the full-fat pattern.</p> <p>Conclusions: This study indicates that both ethnicity and SES are relevant for dietary patterns at age 5 and may enable more specific nutrition education to specific ethnic and low socioeconomic status target groups.</p>		
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1 **Ethnicity and socioeconomic status are related to dietary patterns at age 5 in the**
2 **Amsterdam Born Children and their Development (ABCD) cohort**

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34 **ABSTRACT**

1
2 35 **Background** Health inequalities are already present at young age and tend to vary
3
4 36 with ethnicity and socioeconomic status (SES). Diet is a major determinant of overweight,
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6 37 and studying dietary patterns as a whole in relation to overweight rather than single nutrients
7
8 38 or foods has been suggested. We derived dietary patterns at age 5 and determined whether
9
10 39 ethnicity and SES were both related to these dietary patterns.
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14 40 **Methods** We analysed 2 769 validated Food Frequency Questionnaires filled in by
15
16 41 mothers of children (5.7±0.5y) in the Amsterdam Born Children and their Development
17
18 42 (ABCD) cohort. Food items were reduced to 41 food groups. Energy adjusted intake per food
19
20 43 group (g/d) was used to derive dietary patterns using Principal Component Analysis and
21
22 44 children were given a pattern score for each dietary pattern. We defined 5 ethnic groups
23
24 45 (Dutch, Surinamese, Turkish, Moroccan, other ethnicities) and 3 SES groups (low, middle,
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26 46 high, based on maternal education). Multivariate ANOVA, with adjustment for age, gender
27
28 47 and maternal age, was used to test potential associations between ethnicity or SES and dietary
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30 48 pattern scores. Post-hoc analyses with Bonferoni adjustment were used to examine differences
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32 49 between groups.
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39 50 **Results** Principal Component Analysis identified 4 dietary patterns: a snacking, full-
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41 51 fat, meat and healthy dietary pattern, explaining 21% of the variation in dietary intake.
42
43 52 Ethnicity was related to the dietary pattern scores ($p<0.01$): non-Dutch children scored high
44
45 53 on snacking and healthy pattern, whereas Turkish children scored high on full-fat and
46
47 54 Surinamese children on the meat pattern. SES was related to the snacking, full-fat and meat
48
49 55 patterns ($p<0.01$): low SES children scored high on the snacking and meat pattern and low on
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51 56 the full-fat pattern.
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57 **Conclusions** This study indicates that both ethnicity and SES are relevant for dietary
58 patterns at age 5 and may enable more specific nutrition education to specific ethnic and low
59 socioeconomic status target groups.

61 **Keywords:** dietary patterns, PCA, children, preschool children, ethnicity, socioeconomic
62 status, overweight

64 **BACKGROUND**

65 Health inequalities, such as the prevalence of overweight, are already present at a young age
66 and tend to vary on the basis of ethnicity and socioeconomic (SES) status [1, 2, 3]. Diet is a
67 major determinant of overweight [4, 5, 6], and studying dietary patterns as a whole in relation
68 to overweight rather than single nutrients or foods has been suggested [7, 8, 9].

69 Dietary patterns are population specific and influenced by sociocultural factors and
70 food availability [10, 11]. In recent decades, European populations have become increasingly
71 ethnically diverse and ethnic minority groups are often disproportionate in lower SES groups
72 [12]. The predominant ethnic minority groups, i.e. Turkish, Arabs (North African and Middle
73 Eastern), Berbers and Black Africans (Afro-Caribbean and others by descent), form
74 approximately 3% of the total European population, with the largest numbers in Western
75 European countries [13]. Non-native groups have less often completed higher education than
76 native borns [14] which makes observation of SES differences also of interest.

77 Socioeconomic differences in dietary patterns have been described in adults. In
78 children, SES differences in dietary patterns has been observed in several studies including 4
79 prospective birth cohorts in 3 countries in Europe, i.e. The Avon Longitudinal Study of
80 Parents and Children (ALSPAC) cohort, the EDEN mother-child cohort, the Norwegian
81 Mother and Child Cohort Study and the Southampton Women's Cohort Survey [15, 16, 17,

18, 19, 20, 21, 22, 23]. Data on ethnic differences in dietary patterns among children is limited [24]. To our knowledge, only the ALSPAC cohort identified an association between ethnicity dividing the study population into white and non-white ethnicity [18, 19]. However, the diversity of ethnic groups in Western Europe is more pronounced and we expect to observe differences in dietary intake between ethnic groups [25, 26, 27]. Exploring the potential ethnic diversity as well as socioeconomic differences in dietary patterns in children may provide new and more specific insight for public healthcare professionals to identify groups with poor dietary habits.

Therefore, the aim of the present study was to derive dietary patterns at age 5 in the multi-ethnic Amsterdam Born Children and their Development (ABCD) cohort and to examine potential associations with either or both ethnicity and SES.

METHODS

Study design and study population

Data were used from the ABCD study, a large ongoing community-based birth cohort (<http://www.abcd-study.nl/>). The cohort study design has been described previously [28]. Figure 1 shows the study procedure and inclusion in the current analysis. In brief, between January 2003 and March 2004, all pregnant women living in Amsterdam were invited to participate in the ABCD study by their obstetric care provider at their first parental care visit. Of the 12 373 women approached, 8 266 women filled out a pregnancy questionnaire that covered socio-demographic characteristics, obstetric history, family history and lifestyle, which was available in Dutch, English, Turkish and the Arabic language. When the children turned 5 years of age, 4 488 received a self-administered Food Frequency Questionnaire (FFQ) and a number of 2 851 mothers returned the FFQ. Based on a data clearance protocol set by TNO Food (Zeist, The Netherlands), children were excluded from analysis with more

107 than 50% missing per page or per cluster of food items (n=69). Finally, 13 children were
108 excluded as years of education of the mother was not available in the pregnancy
109 questionnaire, resulting in 2 769 children included in the present analysis.

110 Efforts to enhance participation among all women and children, regardless of ethnicity
111 and education were done by using translated questionnaires and information leaflets. Also,
112 women from ethnic minority groups who did not respond within a month were approached by
113 phone by trained students who explained the study in the women's preferred language.
114 Attrition in follow-up number was largely attributable to untraceable changes in address or
115 migration. This study was approved by the institutional review committee of the Academic
116 Medical Center, and the Registration Committee of Amsterdam. All of the participants gave
117 written informed consent for themselves and their children. The present study was conducted
118 according to the guidelines laid down in the Declaration of Helsinki.

120 **Dietary assessment**

121 A validated 71-item FFQ, developed by TNO Food (Zeist, The Netherlands) was used [29].
122 Per food item, consumption frequency, portion size and the type of product consumed over
123 the last 4 weeks was reported by the mother of the child. Frequency options were "never",
124 "less than once a week", "once a week", "2-3 times a week", "4-5 times a week", and "6-7
125 times a week". Based on the data clearance protocol developed by TNO Food, the returned
126 FFQs were scanned and the data were checked for inconsistencies or extreme values.
127 Impossible values were defined as portion sizes larger than the maximum portion size
128 consumed in the Dutch Food Consumption Survey and were imputed by the mean. For
129 example a maximum of 6 tablespoons of cooked vegetables (180 gram) per day was
130 substituted when a higher amount was filled in. Frequencies and portion sizes were converted
131 into weights (g/day) of product consumed and intake of energy was calculated using the

132 Dutch Food Composition Database (NEVO) 2010 [30]. Each food item in the questionnaire
133 was linked with one or more foods from the Dutch Food Composition Database. In total, a
134 number of 308 different NEVO codes were used for analysis. After calculation of the scanned
135 FFQs, inconsistencies in energy intake for those children with the 5% highest and 5% lowest
136 intake of energy were checked with the original FFQ. When filled in correctly, FFQ's of these
137 children with the highest or lowest energy intake were not excluded as it were plausible levels
138 of energy intakes which might reflect a realistic intake.

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140 **Assessment of ethnicity and socioeconomic status**

141 Data on ethnicity and SES was collected via the pregnancy questionnaire, filled out by the
142 mother during the baseline measurements of the ABCD study. Five ethnic categories were
143 formed: Dutch, Surinamese, Turkish, Moroccan and other ethnicities (mainly non-western
144 origin). We excluded the Surinamese South Asians because of specific body composition and
145 cardiometabolic risk [31]. Ethnicity was based on the country of birth of the pregnant woman
146 and her mother including both first-generation women (born outside the Netherlands) and
147 second generation women (born in the Netherlands but whose mother was born in another
148 country). The pregnant woman's self-registered ethnic origin was used in the Surinamese
149 group and when country of birth of the pregnant woman and her mother were not the same
150 [32].

151 The pregnant women's education after primary school was defined in years and
152 considered as a proxy for SES. Low SES was defined as a maximum of 5 years post-primary
153 education, middle SES as 6-10 years and high SES was defined as more than 10 years of post-
154 primary education [33].

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157 **Assessment of dietary patterns**

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2 158 Principal Component Analyses (PCA) with varimax rotation was used to derive dietary
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4 159 patterns. Food items, including different type of products, were reduced to 41 food groups,
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7 160 based on nutritional value and culinary use. The list with food groups and its type of products
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10 161 can be found in Additional file 1. Products such as gingercake and raisins are often given to
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12 162 children as a healthy alternative for biscuits or candy and were therefore assigned to the food
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14 163 group “healthy snacks”. Because we were interested in the effect of dietary quality
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17 164 independent for its energy content, we adjusted total energy intake using the nutrient residual
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19 165 method [34, 35]. Standardized energy adjusted intake (g/d) of the 41 food groups were used in
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22 166 the PCA analysis. The number of components (dietary patterns) retained was based on the
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24 167 scree plot [see Additional file 2], eigenvalues >1 and the interpretability of the dietary
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26 168 patterns [36, 37]. Food groups with component loadings ≥ 0.3 were considered important for
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29 169 interpretability of the dietary patterns. A larger absolute factor loading indicates a higher
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31 170 positive or negative correlation between the food group and a given dietary pattern. The
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34 171 patterns were named after the nature of the food groups with the highest component loadings
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36 172 within each pattern.

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39 173 Individuals were given a pattern score for each pattern as a sum of the 41 standardized
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41 174 food group intakes, each weighted according to their factor loading. Positive pattern scores
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43 175 indicate higher consumption of food groups in that pattern.
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46 176 47 48 **Statistical analysis**

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51 178 Statistical analyses were performed in SPSS version 22 for windows. Population
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53 179 characteristics were described in percentages or means with standard deviations (SD), shown
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56 180 for the total population and by ethnicity. Univariate and multivariate ANOVA was used to
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58 181 determine whether ethnicity and/or SES were related to dietary patterns with the individual
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182 pattern score of each dietary pattern used as continuous dependent variable and ethnicity or
183 SES used as independent variables (Model 1; crude). The association with ethnicity was
184 additionally adjusted for SES (dummy) and the association with SES was additionally
185 adjusted for ethnicity (dummy) (Model 2). In the fully adjusted model (Model 3) the
186 association with ethnicity was adjusted for age (y), gender, maternal age (y) and SES
187 (dummy) and the analysis with SES was adjusted for age (y), gender, maternal age (y) and
188 ethnicity (dummy). Mean \pm SE pattern scores were shown for each of the dietary patterns by
189 ethnic and SES group separately. Post-hoc analyses with Bonferoni adjustment was used to
190 examine differences between groups. Additionally, we tested for interaction by SES in the
191 association between ethnicity and dietary pattern scores. $P < 0.01$ was considered significant.

192

193 **RESULTS**

194 **Population characteristics**

195 Characteristics of the study population, divided by ethnicity are shown in Table 1. Mean age
196 of the study population was 5.7 ± 0.5 years and 51% of the population was boy. The
197 percentage of children from Dutch origin was 82.4%, followed by Surinamese (4.2%),
198 Moroccan (4.1%), Turkish (2.2%) and other ethnicities (7.1%). The majority of children
199 (53.3%) belonged to the high SES, 35.4% to middle SES and 11.3% to low SES group.

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207 Table 1. Population characteristics in the ABCD cohort by ethnicity (n=2 769).

Population characteristics	Total population (n=2 769)	Dutch (n=2 283, 82.4%)	Surinamese (n=116, 4.2%)	Moroccan (n=112, 4.1%)	Turkish (n=61, 2.2%)	other ethnicities (n=197, 7.1%)
Age, in year (Mean, SD)	5.7, 0.5	5.7, 0.5	5.8, 0.5	6.0, 0.6	5.9, 0.5	5.7, 0.5
Boy, n (%)	1 415 (51.1)	1 166 (51.1)	58 (50.0)	64 (57.1)	34 (55.7)	93 (47.2)
Socioeconomic status, n (%)						
Low	313 (11.3)	145 (6.4)	38 (32.8)	48 (42.9)	33 (54.1)	49 (24.9)
Middle	980 (35.4)	759 (33.2)	57 (49.1)	55 (49.1)	25 (41.0)	84 (42.6)
High	1 476 (53.3)	1 379 (60.4)	21 (18.1)	9 (8.0)	3 (4.9)	64 (32.5)
Maternal age (Mean, SD)	32.3, 4.3	32.8, 3.8	30.6, 5.8	27.9, 4.9	27.1, 6.0	31.5, 4.8

208 Ethnicity was based on the country of birth of the pregnant woman and her mother including both first-generation women and second generation women. SES
209 was based on maternal educational: low SES ($\leq 6y$), middle SES (6-10y) and high SES ($\geq 10y$) post-primary education.

211 Dietary patterns

212 PCA identified 4 dietary patterns in this cohort explaining 20.8% of the variation of dietary
213 intake, according to the Rotated Sums of Squared Loadings. In table 2, an overview of the
214 component loadings from ≥ 0.3 is shown per dietary pattern. The snacking pattern was mainly
215 characterized by high intakes of savory snacks and refined breakfast products and low intakes
216 of whole-grain breakfast products. The full-fat pattern was characterized by high intakes of
217 full-fat spreads and pasta dishes and low intakes of low-fat spreads. The meat pattern was
218 characterised by high intakes of low- and high-fat meat, sauces and refined grain products for
219 warm meals. Finally the healthy pattern was characterised by high intakes on the food groups
220 water and tea, vegetables, fish and fruits.

222 Ethnicity and dietary patterns

223 Ethnicity was significantly related to dietary pattern scores ($p < 0.01$, Table 3). Post-hoc
224 analyses showed that Dutch children had significantly lower (-0.171 ± 0.019 , $p < 0.01$)

225 snacking scores compared to the other ethnic groups, whereas Turkish children had
1 significantly higher (1.363 ± 0.118 , $p < 0.01$) snacking scores. After adjustment for SES the
2 226 associations were less pronounced (-0.124 ± 0.019 for Dutch, 0.998 ± 0.117 for Turkish), but
3 227 still significant for most groups. Further adjustment for age, gender and maternal age did not
4 228 change the results (Table 3). With respect to the full-fat pattern, Turkish children and children
5 229 from other ethnicities had higher pattern scores compared to Moroccan children ($0.283 \pm$
6 230 0.128 and 0.167 ± 0.071 versus -0.247 ± 0.094 , $p < 0.01$), whereas Surinamese children scored
7 231 higher on the meat pattern (0.589 ± 0.092) compared to the other ethnic groups ($p < 0.01$).
8 232 Adjustment for SES did somewhat diminish the associations, but not the level of significance
9 233 (Table 3). Further adjustment for other confounding factors yielded similar results (Table 3).
10 234 The healthy pattern was most pronounced within the groups of Turkish and Moroccan
11 235 children (0.660 ± 0.092 for Moroccan and 0.602 ± 0.125 for Turkish, $p < 0.01$). Adjustment for
12 236 SES and other factors did not change the results.
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240 Table 3. Mean dietary pattern scores by ethnicity in the ABCD cohort (n=2 769).

Dietary pattern	Dutch		Surinamese		Turkish		Moroccan		other ethnicities		Pvalue
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	ANOVA
Snacking											
Model 1: Crude	-0.171	0.019 ^a	0.797	0.086 ^{b,d}	1.363	0.118 ^a	0.819	0.087 ^{b,d}	0.626	0.066 ^{b,d}	<0.01
Model 2: SES	-0.124	0.019 ^a	0.576	0.084 ^b	0.998	0.117 ^{b,e,f}	0.516	0.087 ^{b,d}	0.491	0.064 ^{b,d}	<0.01
Model 3: Fully adjusted	-0.122	0.019 ^a	0.567	0.084 ^b	0.987	0.119 ^{b,e,f}	0.505	0.089 ^{b,d}	0.485	0.064 ^{b,d}	<0.01
Full-fat											
Model 1: Crude	-0.003	0.021	-0.127	0.093	0.283	0.128 ^e	-0.247	0.094 ^{d,f}	0.167	0.071 ^e	<0.01
Model 2: SES	-0.019	0.021	-0.054	0.094	0.409	0.131 ^e	-0.146	0.097 ^d	0.212	0.072	<0.01
Model 3: Fully adjusted	-0.021	0.021 ^d	-0.054	0.094	0.433	0.132 ^{b,e}	-0.136	0.099 ^d	0.217	0.072	<0.01
Meat											
Model 1: Crude	-0.020	0.021 ^c	0.589	0.092 ^a	-0.088	0.127 ^c	-0.001	0.094 ^c	-0.088	0.071 ^c	<0.01
Model 2: SES	0.002	0.021 ^c	0.484	0.093 ^a	-0.253	0.130 ^c	-0.143	0.096 ^c	-0.152	0.071 ^c	<0.01
Model 3: Fully adjusted	0.007	0.021 ^c	0.469	0.093 ^a	-0.297	0.131 ^c	-0.182	0.098 ^c	-0.157	0.071 ^c	<0.01
Healthy											
Model 1: Crude	-0.085	0.020 ^{d,e,f}	0.023	0.091 ^{d,e,f}	0.602	0.125 ^{b,c}	0.660	0.092 ^{b,c}	0.415	0.070 ^{b,c}	<0.01
Model 2: SES	-0.085	0.021 ^{d,e,f}	0.023	0.092 ^{d,e,f}	0.597	0.129 ^{b,c}	0.659	0.095 ^{b,c}	0.415	0.071 ^{b,c}	<0.01
Model 3: Fully adjusted	-0.089	0.021 ^{d,e,f}	0.033	0.092 ^{d,e,f}	0.645	0.130 ^{b,c}	0.703	0.097 ^{b,c}	0.414	0.070 ^{b,c}	<0.01

241 Ethnicity was based on the country of birth of the pregnant woman and her mother including both first-generation women and second generation women.

242 Mean, SE pattern score per dietary pattern by ethnicity.

243 Mean pattern scores for the total group was set to 0.000 based on PCA method.

244 Model 1: unadjusted.

245 Model 2: adjusted for SES.

246 Model 3: adjusted for SES, age, gender and maternal age.

247 Sign (P<0.01) is based on ANOVA and Post-hoc Bonferroni.

248 ^a sign with all groups

249 ^b sign with Dutch

250 ^c sign with Surinamese

251 ^d sign with Turkish

252 ^e sign with Moroccan

253 ^f sign with other ethnicities

255 Socioeconomic status and dietary patterns

256 SES was significantly related to snacking, full-fat and meat dietary pattern scores (p<0.01, Table 4). Post-hoc analyses showed that low SES children had significantly higher snacking pattern scores (0.864 ± 0.052) compared to middle (0.171 ± 0.030) and high SES groups (-0.297 ± 0.024, p<0.01). After adjustment for ethnicity the associations were less pronounced

260 (0.590 ± 0.054 for low SES, 0.137 ± 0.029 for middle SES and -0.216 ± 0.024 for high SES),
 261 but still significant. Further adjustment for age, gender and maternal age did not change the
 262 results. The full-fat pattern was most pronounced within the group of high SES children
 263 (0.055 ± 0.026, p<0.01). The meat pattern was most pronounced in low SES children (0.229 ±
 264 0.056, p<0.01). After adjustment for ethnicity, associations were more pronounced (Table 4).
 265 Further adjustment for age, gender and maternal age did not change the results (Table 4).

Table 4. Mean dietary pattern scores by socioeconomic status in the ABCD cohort (n=2 769).

Dietary pattern	Low SES		Middle SES		High SES		Pvalue ANOVA
	Mean	SE	Mean	SE	Mean	SE	
Snacking							
Model 1: Crude	0.864	0.052 ^a	0.171	0.030 ^a	-0.297	0.024 ^a	<0.01
Model 2: Ethnicity	0.590	0.054 ^a	0.137	0.029 ^a	-0.216	0.024 ^a	<0.01
Model 3: Fully adjusted	0.591	0.054 ^a	0.134	0.029 ^a	-0.214	0.024 ^a	<0.01
Full-fat							
Model 1: Crude	-0.179	0.056 ^b	-0.026	0.032	0.055	0.026 ^c	<0.01
Model 2: Ethnicity	-0.217	0.060 ^b	-0.028	0.032	0.065	0.027 ^c	<0.01
Model 3: Fully adjusted	-0.213	0.060 ^b	-0.025	0.032	0.061	0.027 ^c	<0.01
Meat							
Model 1: Crude	0.229 ^b	0.056	0.098	0.032 ^b	-0.114	0.026 ^a	<0.01
Model 2: Ethnicity	0.242	0.060 ^b	0.096	0.032 ^b	-0.115	0.026 ^a	<0.01
Model 3: Fully adjusted	0.231	0.060 ^b	0.093	0.032 ^b	-0.111	0.026 ^a	<0.01
Healthy							
Model 1: Crude	0.217	0.056 ^a	0.004	0.032 ^c	-0.049	0.026 ^c	<0.01
Model 2: Ethnicity	0.025	0.059	-0.019	0.031	0.008	0.026	0.716
Model 3: Fully adjusted	0.043	0.059	-0.019	0.031	0.003	0.026	0.618

SES was based on maternal educational: low SES (<6y), middle SES (6-10y) and high SES (>10y) post-primary education.

Mean, SE pattern scores per dietary pattern by socioeconomic group.

Mean pattern scores for the total group was set to 0.000, based on PCA method.

Model 1: unadjusted.

Model 2: adjusted for ethnicity.

Model 3: adjusted for ethnicity, age, gender and maternal age.

Sign (P<0.01) is based on ANOVA and Post-hoc Bonferroni.

^a sign with all groups

^b sign with high SES group

^c sign with low SES group

280 **Ethnicity, socioeconomic status and dietary patterns**

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2 281 The main positive significant associations between ethnicity, SES and dietary patterns in the
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4 282 fully adjusted model are shown in figure 2. We tested for interaction between SES and
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7 283 ethnicity in relation to pattern scores and found a borderline significant interaction for the
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9 284 full-fat ($p=0.018$) and meat pattern ($p=0.017$), whereas no interaction was present for the
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11 285 snacking ($p=0.324$) and healthy ($p=0.260$) pattern. Profile plots showed that both ethnicity
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13 286 and SES were independent related to dietary patterns [See Additional file 3].
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18 19 288 **DISCUSSION**

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21 289 We have identified four dietary patterns in the large multi-ethnic ABCD cohort, consisting of
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23 290 2 769 children. Already at age 5, both ethnicity and SES were independently related to dietary
24
25 291 patterns. Non-Dutch had high snacking and healthy pattern scores, whereas Turkish children
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27 292 scored higher on full-fat and Surinamese children scored higher on meat pattern scores. Low
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29 293 SES children had high snacking, meat and low full-fat pattern scores. Both ethnicity and SES
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31 294 seem to contribute independently to the differences in dietary patterns.
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37 38 39 296 **Interpretation and comparison with previous studies**

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41 297 Results of a systematic review including 14 publications utilizing PCA in 1-8 year old native
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43 298 children in mainly European countries [15] showed that most studies identified between two
44
45 299 and six dietary patterns, with the majority of studies identifying a healthy,
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47 300 unhealthy/processed/snacking, and local/traditional pattern [5, 15, 22, 38]. Among the cohorts
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49 301 that evaluated the diets of children aged 3-5 years, a healthy and unhealthy pattern were most
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51 302 often identified [15, 17, 21, 38, 39, 40, 41, 42] with similar dietary patterns as the healthy and
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53 303 snacking pattern, which were observed in the present analysis. Our full-fat pattern shows
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57 304 similarities with the varied traditional Norwegian pattern, found by Oellingrath in 9-10 year
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305 old Norwegian children, which was characterized by high component loadings on full-fat
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2 306 cheese and full-fat spreads [5], food groups that also characterized the full-fat pattern in this
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5 307 study.

6
7 308 We have identified an association between ethnicity and dietary patterns. Up to now,
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10 309 data on the association between ethnicity and dietary patterns has been scarce. In ALSPAC a
11
12 310 snacking pattern was related to white ethnicity at age 3 and 7 [17, 19] and a healthy pattern
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14 311 with non-white ethnicity at age 4 to 7 years [19]. We found both higher healthy and snacking
15
16 312 pattern scores in non-Dutch groups. In the Netherlands, the consumption of fruit and
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19 313 vegetables is higher in 7-9 year old children from Turkish and Moroccan origin [43] and 9-10
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22 314 year old children from non-western origin [44] than that of Dutch children. However also
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24 315 consumption of snacking items and soft drinks has been found to be higher in 5-6y old non-
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26 316 ethnic groups, mainly of Turkish origin [42] which is in line with findings in our study.
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29 317 Additionally, the present study showed a full-fat and a meat pattern. Surinamese children
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31 318 have higher meat pattern scores than children from other ethnic groups and Turkish children
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33
34 319 have higher full-fat pattern scores. It has been reported in Dutch National Food Survey's that
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36 320 intake of fat and full-fat dairy products is high among groups from Turkish origin [25, 26].
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39 321 Several studies have observed SES differences in dietary patterns in children [15, 16,
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41 322 17, 18, 19, 20, 21, 22, 23] with maternal education being the most important variables [18,
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43 323 21]. In four large prospective birth cohorts (ALSPAC, the EDEN mother-child cohort, the
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45 324 Norwegian Mother and Child Cohort Study and the Southampton Women's Cohort Survey)
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48 325 healthier dietary patterns in young children (1-7y) were associated with higher maternal
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51 326 education [17, 19, 21, 23, 39]. We did not find significantly different healthy pattern scores
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53 327 between SES groups however low SES children had higher healthy pattern scores than middle
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56 328 and high SES groups. In the ALSPAC cohort, the junk pattern at age 4 and 7 was more likely
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58 329 when maternal education level was low [20]. In line with these findings, we found that low
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330 SES children have higher snacking pattern scores. Our high SES children had higher full-fat
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2 331 pattern scores (full-fat spreads, full-fat cheese and refined pasta dishes) and low meat pattern
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4 332 scores (low- and high fat meat, sauces and refined grain products for warm meals). We did
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7 333 not find other studies describing this full-fat dietary pattern in high SES children.
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9 334 In the present study, the non-Dutch groups (Surinamese, Turkish, Moroccan and other
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11 335 ethnicity) came disproportionately from lower SES groups (Table 1). Although ethnicity and
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13 336 SES are strongly correlated, we showed that both ethnicity and SES explained differences in
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15 337 dietary pattern scores between groups at age 5y. This suggests that both ethnicity and SES
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17 338 seem to be a predictor for adherence to a specific dietary pattern.
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24 340 **Methodological consideration**

25
26 341 A problem common in studies using the PCA method is that the number of dietary
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28 342 patterns is based on scree plots, eigenvalues and the interpretability of the dietary patterns
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30 343 which is a limitation in objectivity [45]. The labelling of the identified patterns is subjective,
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32 344 which can be judged by the reader from the presented component loadings (Table 2). The 4
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34 345 identified dietary patterns in this cohort explained 20.8% of the variation of dietary intake
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36 346 which is common in studies using the PCA method.
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41 347 FFQs are considered an appropriate method for population-based evaluations of
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43 348 dietary patterns in childhood and are favored in large-scale studies because they are less
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45 349 burdensome to participants and reduce post-collection processing of dietary data [27]. A
46
47 350 possible limitation is that the FFQ was based on food commonly consumed by the Dutch
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49 351 population as determined by the Dutch Food Consumption Survey 1997–1998 [46]. However
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51 352 subanalysis showed that energy intake related to energy requirements (based on Schofield
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53 353 resting metabolism) was not different between Dutch and non-Dutch groups. It might be
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55 354 possible that some ethnic specific food items were not registered by the mother. The open
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355 question at the end of the FFQ gave the mother the opportunity to register consumed food
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2 356 items that were not literally asked in the 71-items. Based on methodological considerations
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4 357 (not all mothers filled-in this open question and there was the risk of double registration), we
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7 358 decided to not analyse these registered items. The FFQ was validated with the gold standard
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10 359 of doubly labelled water in a group of 4- to 6-year-old children, who did not exactly reflect
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12 360 the non-Dutch groups [29].
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14 361 The present study had a response rate of 33% of the original cohort. Smaller numbers
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17 362 in ethnic groups is inherent to the ABCD study design but it is possible that some biases may
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19 363 have been introduced into the analyses, particularly as the nonresponders tended to come
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22 364 disproportionately from lower SES and ethnic minority groups that consumed more according
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24 365 to the snacking pattern. Response rates per ethnic and SES group were 53% for Dutch, 23%
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27 366 for Surinamese, 14% for Turkish, 15% for Moroccan, 9% for other ethnicities, 16% for low
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29 367 SES, 31% for middle SES and 47% for high SES. A nonresponse analysis determining the
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32 368 degree of selective response and selection bias between pregnancy and birth outcomes,
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34 369 indicated that selective non-response was present in the ABCD-study, but selection bias was
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36 370 acceptably low and did not influence the studied birth outcomes [47].
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38
39 371 Strengths of this study includes the sample size of 2 769 children in which dietary
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41 372 pattern analyses was performed. The present study is one of few that provides insight into
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44 373 dietary patterns in children in a multi-ethnic population.
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51 376 **Implications for research and interventions**

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53 377 In this group of young children, we identified specific ethnic and SES groups that consumed
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56 378 more according to unfavourable dietary patterns. Dietary tracking, the maintenance of a
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58 379 dietary pattern over a certain time period, has been observed during childhood and from
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380 childhood to adolescence and unhealthy eating habits have been found to track into
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2 381 adolescence and adulthood.
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4 382 Dietary habits are a major determinant of overweight [4, 5]. Non-native, especially
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7 383 children of Turkish origin, and low SES groups show higher adherence to the unfavourable
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9 384 snacking pattern and show disproportionately higher prevalence of overweight and obesity (7%
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11 385 for Dutch, 14% for Surinamese, 25% for Turkish, 23% for Moroccan, 17% for low SES, 12%
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13 386 for middle SES and 8% for high SES) at age 5 [48]. Future studies could analyze the
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15 387 explanatory factors in early childhood contributing to these (differences in) dietary choices
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17 388 and the possible relationships these dietary patterns may have with weight development and
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19 389 health inequalities in later childhood.
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26 391 **CONCLUSION**

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29 392 This study indicates that both ethnicity and SES are relevant for dietary patterns at age 5 and
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31 393 may enable more specific nutrition education to specific ethnic and low SES target groups, in
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33 394 order to avoid overweight and other health inequalities.
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41 397 **LIST OF ABBREVIATIONS**

42
43 398 **ABCD:** Amsterdam Born Children and their Development
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46 399 **SES:** socioeconomic status
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48 400 **ANOVA:** Analysis of Variance
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51 401 **ALSPAC:** The Avon Longitudinal Study of Parents and Children
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53 402 **FFQ:** Food Frequency Questionnaire
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55 403 **PCA:** Principal Component Analysis
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405 **DECLARATIONS**

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407 **Ethics approval and consent to participate**

408 All participants gave written informed consent for themselves and their children.

409

410 **Consent for publication**

411 Not applicable.

412

413 **Availability of data and materials**

414 Data are not publically available due to ethical restrictions related to protecting patient
415 confidentiality. The datasets analysed during the current study are available from the
416 corresponding author on reasonable request.

417 **Competeting interest**

418 The authors declare they have no competing interests.

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423 in Amsterdam, The Netherlands.

424

425 **Authors' contributions**

426 V.R., M.v.E., P.J.M.W, A.P.V., formulating the research questions and designing the study;

427 V.R., M.v.E., M.F.E., L.H.D analysing the data; V.R., M.F.E., M.v.E., M.N, L.H.D, P.J.M.W,

428 A.P.V, writing the article; and V.R, M.F.E, P.J.M.W had primary responsibility for final
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2 429 content. All authors read and approved the final manuscript.
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TABLES

440 Table 2 should appear in the manuscript in the results section, under the tekst with the Dietary
 441 patterns heading.

Table 2. Component loadings (≥ 0.3) of the 41 food groups per dietary pattern.

	Dietary patterns			
	Snacking	Full-fat	Meat	Healthy
Explained variance (%)	7.1	4.6	4.6	4.4
Savory snacks	0.47	-	-	-
Refined breakfast products	0.45	-	-	-
Ice cream	0.42	-	-	-
Sauces	0.41	-	0.35	-
Chocolate and candy	0.38	-	-	-
Fruit drink	0.31	-	-	-
Full-fat dairy	0.30	-	-	-
Low-fat spreads	-0.38	-0.55	-	-
Sandwich toppings (sweet)	-0.38	-	-	-0.33
Whole grain breakfast products	-0.74	-	-	-
Tomato sauce for pasta	-	0.61	-	-
Full-fat spreads	-	0.48	-0.30	-
Refined grain products warm meal	-	0.46	0.34	-
Full-fat cheese	-	0.37	-	-
Low-fat cheese	-	-0.35	-	-
Low-fat meat	-	-	0.44	-
High-fat meat	-	-	0.39	-
Healthy meals	-	-	0.31	-
Boiled potatoes	-	-	0.30	-
Unhealthy meals	-	-	-0.32	-
Peanut butter	-	-	-0.34	-
Water and tea	-	-	-	0.48
Vegetables	-	-	-	0.47
Fish	-	-	-	0.46
Fruits	-	-	-	0.38
Whole grain products warm meal	-	-	-	0.36
Nuts	-	-	-	0.31
Pulses	-	-	-	0.30
Artificially sweetened sodas	-	-	-	-
Biscuits and pastries	-	-	-	-
Egg	-	-	-	-
Fried potato products	-	-	-	-

	Fruit drink concentrate	-	-	-	-
1	Granola bars	-	-	-	-
2	Healthy snacks	-	-	-	-
3	Low-fat dairy	-	-	-	-
4	Meat alternatives and soy products	-	-	-	-
5	Medium-fat dairy	-	-	-	-
6	Processed meats	-	-	-	-
7	Sugar	-	-	-	-
8	Sugar sweetened sodas	-	-	-	-
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a. Rotation converged in 12 iterations.

Component loadings (≥ 0.3) were considered important for interpretability of the dietary patterns. A larger factor loading indicates a higher positive or negative correlation between the food group and dietary pattern.

FIGURE LEGENDS

Figure 1. Flowchart of the inclusion into the present analysis (n=2 769).

Figure 2. The main positive significant associations between ethnicity, SES and dietary patterns (n=2 769).

Figure 1

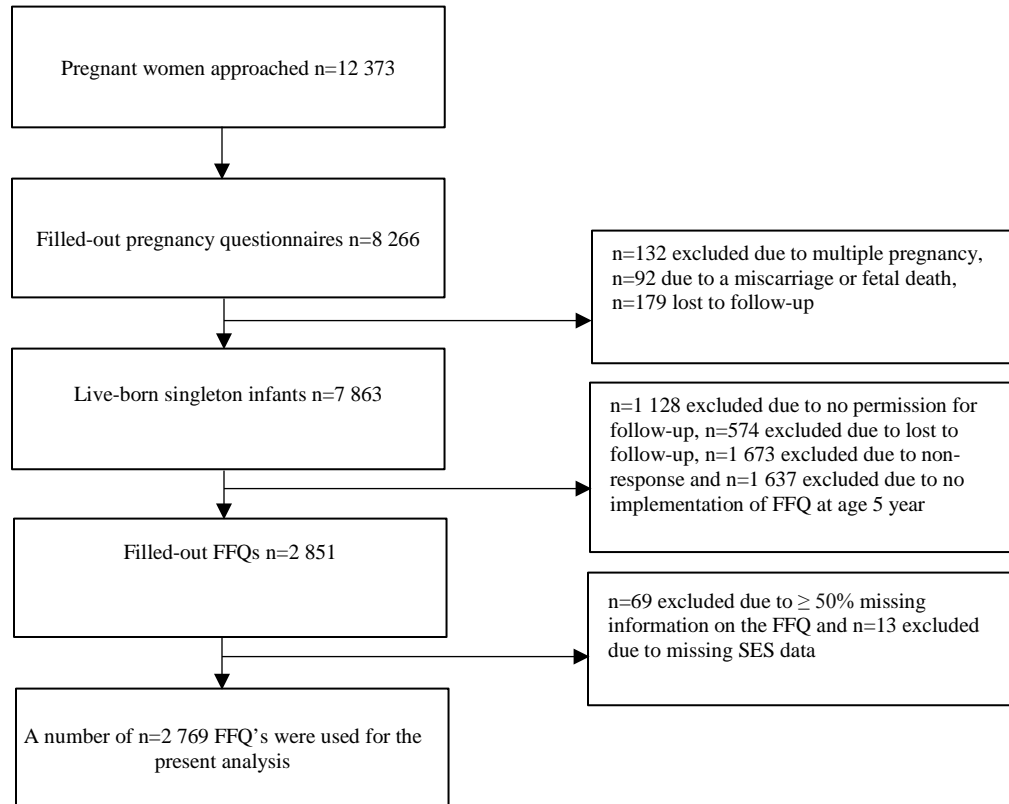
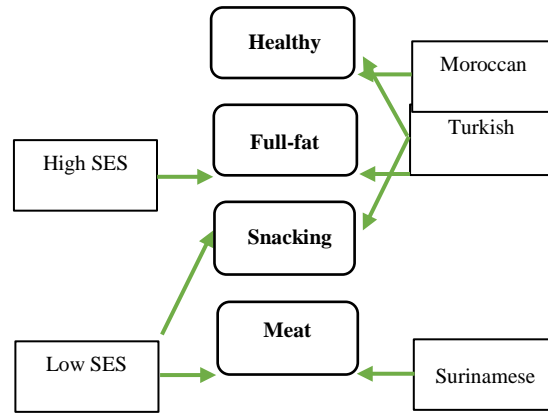
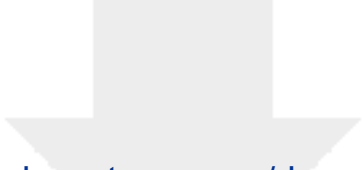
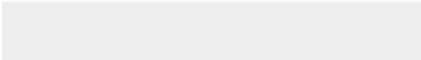




Figure 2







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