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Dietary pattern longitudinality during 8 years in children: results from the European Longitudinal Study of Pregnancy and Childhood (ELSPAC–CZ)

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Abstract

Objective: Dietary pattern analysis constitutes a suitable method for identifying complex food preferences as well as a useful tool for comparing dietary behaviour across individual populations. In addition to a lack of information on Central European dietary patterns, dietary data featuring a longitudinal aspect are likewise largely unavailable for the region. Our study thus strives to address this gap by analysing children's dietary patterns, their stability and possible changes at 7, 11 and 15 years in the Czech part of the European Longitudinal Study of Pregnancy and Childhood (ELSPAC–CZ).

Design: We analysed dietary data based on the self-reported semi-quantitative FFQ obtained in 1998, 2002 and 2006. Dietary patterns were derived using factor analysis for each period, followed by the determination of dietary pattern stability across the individual periods.

Setting: The analysis of dietary patterns was based on longitudinal children's dietary data from the geographical region that was undergoing massive socio-economic changes at the time of birth of the study subjects.

Participants: All participants were children. At 7 years the analysis included 3220 children, at 11 years the analysis included 2509 children and at 15 years the analysis included 1589 children.

Results: Two stable children's dietary patterns labelled as 'prudent' and 'junk food' were identified across all three time points (7, 11 and 15 years).

Conclusions: This study identifies stable longitudinal trends in the dietary behaviour of children enrolled in the ELSPAC-CZ study.

Keywords
Dietary patterns
FFQ
Longitudinality
European Longitudinal Study of Pregnancy and Childhood
Cohort study
Children
Diet

Poor diet in early life is a major modifiable risk factor with a multitude of health outcomes. Although numerous studies have focused on the association between defined health outcomes and diet, many of these studies are frequently plagued by methodological discrepancies and often feature a cross-sectional design which represents a limitation when attempting to interpret long-term trends[1]. The geographical location of a given country is also an important factor influencing the quality of data, as in some areas data collection had been hindered due to political reasons for a long time. With some exceptions, such as the HAPIEE study (Health, Alcohol and Psychosocial factors In Eastern Europe), which focused primarily on the elderly[2], this long-term lack of quality follow-up on the dietary characteristics of country-wide populations as well as specific subpopulations also applies to Central Europe. Even though a recent large-scale study performed on data from nineteen countries focused on clustering energy balance-related behaviours and on associating identified clusters with weight status using data on the fruit and vegetable intake of Eastern European children and adolescents[3], complex evaluation of the diet and especially its longitudinal outcomes in children is largely missing[4–8].

Some information on the dietary behaviour of Central European children comes from a Czech study entitled Health Behaviour in School-aged Children. While the

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Health Behaviour in School-aged Children study focused on the consumption of fruit, vegetables, soft drinks and sweets by Czech children and adolescents from 2002 to 2014[9], it did not focus specifically on dietary patterns. Recently, the dietary patterns of pregnant women enrolled in the European Longitudinal Study of Pregnancy and Childhood (ELSPAC–CZ) study were analysed by Bienertová-Vašků *et al.*[10]. However, longitudinal studies describing the dietary patterns of children are currently missing. Moreover, this lack of data must also be viewed in the context of major socio-economic and political changes which took place in Central Europe beginning with the early 1990s: these extensive and profound changes may be expected to have resulted in substantial dietary behaviour changes within the space of the past 20 years.

In the 1990s, Czech society underwent a unique transition from a planned economy to a market-based system; this historical occurrence may be viewed as a suitable basis for studying the impact of socio-economical changes on the dietary behaviour of entire families[11]. Like most Central and Eastern European countries, Czechoslovakia (subsequently split into the Czech Republic and Slovakia) experienced a transitional recession period in the early 1990s as a result of an inflation rate jump. While unemployment rose steeply in Slovakia during the recession of 1991–1992 (14·7 % in 1993), it remained stable in the Czech Republic (4 % in 1993). Although the Czech Republic and Slovakia experienced a rise in income inequality during the transition period[11], second-generation reform policies adopted by the Czech government to correct the shortcomings of first-generation reforms subsequently led to sustained economic growth beginning with the mid-1990s.

In order to address the issue of dietary pattern stability in a profoundly changing population undergoing a major socio-economic transformation, this study aims to investigate the longitudinal aspects of dietary behaviour – assessed in the form of dietary patterns – between 1991 and 2006 in the ELSPAC–CZ. This study specifically aims to investigate: (i) the dietary patterns of children at 7, 11 and 15 years of age, (ii) the stability (level of adherence) of the observed patterns throughout a follow-up period of 8 years and (iii) the predisposing factors for identified dietary patterns in the observed population.

Methods

Study design

The ELSPAC is a population-based study examining the effects of biological, psychosocial, economic and environmental factors; the study focuses on how these factors affect the health and development of children from the prenatal period to adulthood. The study was initiated by the World Health Organization Regional Office for Europe in 1985 with the aim of collecting data from 40 000 children across Europe[12]. The project was originally coordinated by Bristol University – Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC)[13] – and operated by eight independent centres based in the UK, Czechoslovakia, Greece, Ukraine and Russia (the latter two were initially part of the USSR). Protocol development, including follow-up planning and questionnaire design, was coordinated by ALSPAC[14]. The Czech portion of the study (ELSPAC-CZ) included eligible mothers from the Brno (the second largest city in the Czech Republic) that was home to 389 000 inhabitants in 1991–1992[15]. All participating mothers were expected to deliver between 1 April 1991 and 30 June 1992. Self-reported questionnaires filled out by participants included records of demographics, lifestyle, dietary habits, partnership, life attitudes, life events, social factors and environmental exposure. In addition to its primary aims, the Czech ELSPAC–CZ study also examined socio-economic changes related to the societal transformation after the fall of Communism in 1989[10,14].

Exclusion criteria and final sample size

The analysis presented in this study is based on data collected from the mothers in the study who reported on their children at two time points: 7 and 11 years. The children themselves reported on their dietary behaviour at 15 years of age. For ease of reporting, we will refer to these time points as 7, 11 and 15 years throughout the paper. The cases (children of reporting mothers or the reporting children themselves at 15 years) were excluded from the analysis in case the absolute values of their factor scores exceeded 3·5. A total of 0·9 % of all subjects were excluded from the study as a result of extreme factor scores. At 7 years, the analysis thus included 3230 children, at 11 years the analysis included 2509 children and at 15 years the analysis included 1589 children.

Dietary assessment

Dietary data were obtained from a self-reported semi-quantitative FFQ (SFFQ) collected according to the ELSPAC–CZ protocol from all study participants. The SFFQ was based on ALSPAC SFFQ, with several local food items added. Data were collected from children at three time points. Mothers were asked to fill in SFFQ about each child's diet around the seventh and eleventh birthday of their child. The children were asked to fill out the SFFQ themselves at 15 years of age.

Participants were asked to indicate consumption frequency for 40–60 food questions using the following criteria: (1) never or rarely; (2) twice a month; (3) one to three times per week; (4) four to seven times per week and (5) several times a day. Participants were also asked to report portion sizes. For factor analysis purposes, a score for each component was created by multiplying

the factor loadings by a standardised value for each food item and summing through all food items. All food items were divided into thirty-nine food groups. Food groups with no detectable effects were removed for greater clarity. This method has been used before, for example, by the HAPIEE study[2,10]. A detailed description of food item grouping across investigated time periods is provided in Supplemental Table 1.

Statistical analysis

Children's dietary patterns were estimated by exploratory factor analysis with varimax rotation for thirty-nine food groups. The Kaiser–Olkin–Meyer test was used to identify whether factor analysis results were appropriate. When a suitable number of factors were identified for a given group and period, factor scores were extracted. To determine the longitudinal stability of individual dietary patterns, factor analysis was performed again, this time with extracted factor scores from the previous analysis. The Pearson correlation coefficient was used to assess the association between extracted factor scores for a given pair of dietary patterns across observed time periods. This method was selected due to the high dropout rate of subjects when considering analyses of full cases from cross-sectional and longitudinal point of view. Food groups with absolute factor loadings greater than 0·20 for a given dietary pattern were considered to significantly contribute to the pattern, and conversely, negative loadings lower than −0·2 were considered to contribute inversely to the dietary pattern. All analyses were performed using R software, version 3.3.3. *P*-values of less than 0·05 were considered statistically significant.

Results

Descriptive results

Description of the biological characteristics of the children in the study is given in Table 1. The percentage of total variance the dietary patterns account for stood at 14·8 % at 7 years, 20·4 % at 11 years and 25·5 % at 15 years.

Children's dietary patterns

Three dietary patterns were identified at the three examined time points (7, 11 and 15 years). The pattern scores at each time point are provided in Table 2. Consumption at 7 years was characterised by two dietary patterns, labelled 'prudent' and 'junk food'. Consumption at 11 years was characterised by three dietary patterns, labelled 'junk food', 'prudent 1' and 'prudent 2'. Consumption at 15 years was characterised by two dietary patterns, labelled 'junk food' and 'prudent'. Although three separate patterns were thus identified, two dietary patterns were found to be consistently present in children across all three time points: the 'junk food' and the 'prudent' pattern. The trajectories of children's dietary patterns across each time period and between individual time periods

Table 1 Non-dietary characteristics of children

	7 years				11 years				15 years			
	Girls		Boys		Girls		Boys		Girls		Boys	
Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
n	1371		1445		1048		1040		716		687	
Age (years)	7·0	0·1	7·0	0·1	11·0	0·1	11·0	0·1	15·0	0·1	15·0	0·1
Birth weight/weight (kg)	24·1	4·1	25·0	4·2	39·3	8·5	39·3	8·3	56·5	8·7	62·1	11·7
Birth length/height (cm)	124·5	5·8	125·5	5·4	148·7	7·4	148·1	6·6	165·9	6·5	174·6	7·4
BMI (kg/m^2)	15·5	1·9	15·8	2·0	17·7	2·9	17·8	2·9	20·5	2·9	20·3	3·1
Prudent pattern 1	0·02	0·96	−0·02	1·04	0·03	0·96	−0·01	1·05	0·00	0·98	0·01	1·00
Prudent pattern 2	–		–		0·03	1·00	−0·04	0·97	–		–	
Junk food	−0·03	0·98	0·02	1·01	−0·04	1·01	0·02	0·97	−0·24	0·98*	0·24	0·96*
Height *z*-score (–)												
Mean	0·65				0·62				0·66			
SD	1·01				1·04				0·94			
BMI *z*-score (–)												
Mean	−0·01				0·06				−0·02			
SD	1·11				1·18				1·00			
					n	%	*n*	%	*n*	%	*n*	%
Maternal education: completed primary school		Unknown			262	26·4	282	28·4	133	19·2	142	21·2
Maternal education: completed secondary school		Unknown			456	45·9	434	43·8	343	49·6	313	46·8
Maternal education: completed university		Unknown			276	27·8	276	27·8	216	31·2	214	32·0

Height *z*-score, height-for-age *z*-score; BMI *z*-score, BMI for-age *z*-score.
*Statistically significant difference, $P < 0.001$.

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Table 2 Factor loading scores for relationships between food groups and children's dietary patterns*

Children's dietary patterns							
Age	7 years		11 years			15 years	
Food groups	JF	PP	JF	PP1	PP2	JF	PP
White bread						0·22	
Whole-wheat bakery products		0·40					
Breakfast cereals		0·38			0·29		0·45
Biscuits	0·51		0·58			0·52	
Yoghurts, puddings	0·20	0·45			0·69	0·28	0·45
Pies and cakes	0·24		0·45		0·22	0·41	0·23
Poultry		0·35		0·34		0·27	0·25
Red meat				0·31		0·29	0·20
Pâtés/ground meat	0·35					0·63	
Offal, giblets				0·24		0·32	0·30
Sausages	0·36		0·23			0·44	
Pizza	0·31					0·58	
Fish		0·42		0·39	0·22		0·47
Molluscs	0·20						
Eggs		0·23		0·28		0·31	0·34
Cheese		0·33			0·63		0·32
Legumes		0·43		0·43			0·52
Nut and seeds	0·25	0·25	0·33	0·23		0·35	0·41
French fries	0·53					0·68	
Boiled potatoes		0·27		0·26			0·32
Dumplings	0·23			0·37		0·30	0·34
Pasta		0·39		0·55			0·45
Rice		0·40		0·56			0·43
Vegetables		0·59		0·36	0·46		0·62
Root vegetables		0·51					
Fresh fruit		0·43			0·53		0·56
Fresh juice		0·31	0·21			0·32	0·42
Cola	0·47		0·34			0·63	
Tea							0·31
Herbal tea		0·20					0·39
Sweeteners	0·25						
Chocolate	0·48		0·62			0·65	
Sweetmeats	0·36		0·61			0·60	
Ice-cream		0·39				0·57	
Ketchup, mustard	0·41		0·40				
Milk		0·31			0·38		0·31
Soft drinks	0·41		0·40			0·50	
Salty snacks	0·48		0·56			0·68	
Desserts			0·48			0·59	0·21

PP, prudent pattern; JF, junk food; PP1, prudent pattern 1; PP2, prudent pattern 2.
*Factor loadings with absolute value <0·2 not shown.

are provided in Fig. 1. A description of the full cases represented by all 1364 children with dietary patterns available across all three time points is provided in Fig. 2.

An analysis of correlations across investigated time points showed the consistent presence of the 'prudent' pattern across all three time points. The 'junk food' dietary pattern was consistently characterised by typical high-fat and high-sugar foods. The correlation obtained using the Pearson correlation coefficient (0·85) showed the robust presence of the 'junk food' dietary pattern across investigated time points.

Furthermore, the calculated factor scores were evaluated using the univariate regression models in relation to socio-economic and maternal biological factors (Supplemental Table 2). Maternal age at birth, maternal education, maternal BMI before pregnancy, substance abuse, alcohol consumption, smoking and relationship status were analysed. Although no significant associations were observed for the first two time points in the study, some of the evaluated variables were significantly correlated with the presence of the 'junk food' pattern at 15 years: maternal education (6·82 %), maternal age at birth (6·24 %), maternal BMI before pregnancy (6·08 %), substance abuse (5·31 %), maternal alcohol intake during pregnancy (5·48 %), maternal smoking during pregnancy (5·80%) and maternal relationship status (5·05 %) (multiple R^2 values in the linear regression model for the variable determining the factor score in dependency on gender, evaluated variable and their interaction).

We also investigated the relationship between the drop-out of children between investigated time points and other above-mentioned variables. Dropout between 7 years and 11 years was significantly associated with maternal age (non-missings were older than missings by approximately

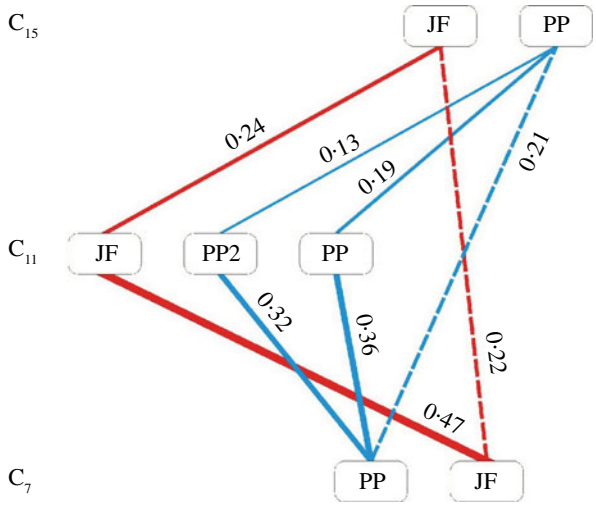

Fig. 1 (colour online) Stability and changes in children's dietary patterns across three time periods. The reported values are the Pearson pairwise correlation coefficient for a pair of factor scores corresponding to given dietary patterns across the investigated time points. Only statistically significant correlations are shown. PP1, prudent pattern 1; JF, junk food; PP2, prudent pattern 2; c_7, children's 7 years time period; c_{11}, children's 11 years time period; c_{15}, children's 15 years time period. Line thickness is directly proportional to the correlation coefficient value. Solid lines connect two adjoining time periods (7–11 and 11–15). Dashed lines connect other time periods (7–15)

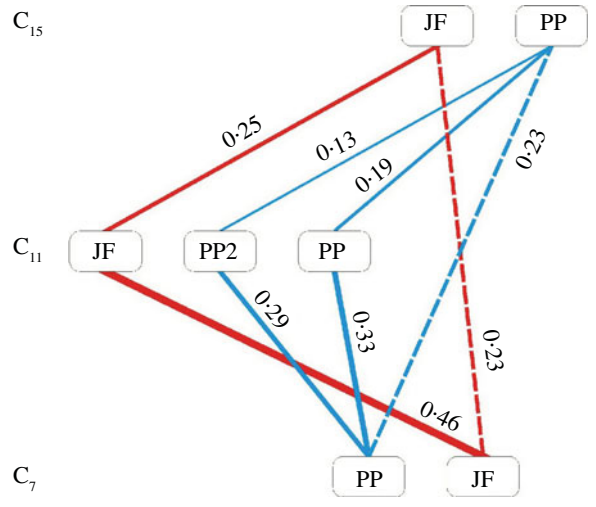

Fig. 2 (colour online) Stability and changes of children's dietary patterns from the total of 1364 children across all three time points. The reported values are the Pearson correlation coefficients for a pair of factor scores in full case analysis (where DP is known in all three ages) corresponding to given dietary patterns. Only statistically significant correlations are shown. PP1, prudent pattern 1; JF, junk food; PP2, prudent pattern 2; c_7, children's 7 years time period; c_{11}, children's 11 years time period; c_{15}, children's 15 years time period. Line thickness is directly proportional to the correlation coefficient value. Solid lines connect two adjoining time periods (7–11 and 11–15). Dashed lines connect other time periods (7–15)

0·4 years), 'junk food' pattern score at 7 years (missings had higher scores than non-missings), sex of the child (non-missings: men and women were approximately equally likely to continue, missings: men were more likely to drop out, OR = 1·23) and maternal education (children of parents with higher education were more likely to continue in the study). Dropout between 11 and 15 years was significantly associated with maternal age (non-missings were older than missings by approximately 0·9 years), maternal height (non-missings were approximately 0·7 cm higher than missings), maternal BMI before pregnancy (missings had higher BMI than non-missings by approximately 0·3 kg/m^2), 'junk food' pattern score at 11 years (missings had higher scores than non-missings), sex of the child (women were more likely to be non-missings, whereas men were more likely to be missings, OR = 1·18), maternal prenatal smoking status (more never smokers were found in the non-missing group) and maternal and paternal education (children of parents with higher education level were more likely to continue in the study).

Discussion

This study is the first to identify stable long-term trends in the dietary behaviour of children in a Central European longitudinal cohort in times of socio-economic transition. This study utilises data from the ELSPAC-CZ cohort, collected in 1998, 2002 and 2006, to analyse children's dietary patterns as well as their stability and changes at ages 7, 11 and 15 years. We analysed dietary data obtained using self-reported SFFQ and derived dietary patterns using factor analysis. We identified two stable dietary patterns in our study population of children (adolescents) which corresponded to patterns established in an ALSPAC population using the same methodology.

Study limitations include a significant dropout number among study subjects which may have biased the remaining data (discussed in detail in the Results). A second major limitation concerns the possible differences between data reported by proxies (mothers) at ages 7 and 11 and data reported by the study participants themselves at age 15. A third limitation is posed by the distribution of SFFQ, submitted once per time point, and thus potentially incapable of recording all seasonal variations in food consumption. The last limitation of the study, that is, the unstable setting of a country transitioning from a planned economy to a market-based system, is also its greatest strength. It could be expected that a transition associated with rising social inequality and liquidity should have a profound effect on both nutritional composition and eating behaviours. However, it seems that within the observed period of almost two decades after the Velvet Revolution, the composition of children's diets remained relatively very stable, corresponding to patterns observed in the UK using the same methodology.

We observed two main stable patterns – a health-conscious one, labelled as 'prudent', and a 'junk food'

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pattern – which was consistently present across all three time points. While the 'junk food' pattern was consistently associated with higher consumption of biscuits, pies and cakes, sausages, cola and other soft drinks, and salty snacks, the 'prudent' pattern was associated with the consumption of breakfast cereals, yoghurts, fish, cheese, vegetables and fresh fruit and milk. Except for the absence of other types of meat than the red meat, the 'prudent' pattern is consistent with food pyramid-based recommendations valid at that time. It could be speculated that as the range of food items gradually expanded and the availability of various snacking options increased, pronounced changes in dietary behaviour of the study subjects would take place as a result of increased marketing pressure. However, no such occurrence was observed in this study, with observed dietary patterns remaining quite stable. It may thus be speculated that family dietary patterns have a more pronounced influence on children's diets than food item availability or massive marketing. However, it could also be suggested that the specific dietary of the family was due to other confounding variables.

In view of the above-mentioned profound socio-economic transformation, it is rather surprising that the results of this study bear a striking similarity to outcomes reported in studies focusing on ALSPAC[5]. The results of such comparisons are even more compelling taking into account that the ELSPAC study generally used the same methodology in terms of the wording of the questionnaires as well as the frequency of administration to both the probands of the study and their proxies. Existing ALSPAC studies[4,5,16–18] reported very similar dietary pattern ranges, which further supports the observation that patterns observed in the UK and in the Czech Republic were quite conserved. The greatest degree of similarity between ELSPAC and ALSPAC was observed between children's dietary patterns labelled 'prudent', that is, 'healthy'[5,17], 'health-conscious'[4], 'health aware'[16] and 'traditional/health-conscious'[4] and between children's dietary patterns labelled 'junk food' in this study, that is, 'processed'[4,5,17]. Taking into account the entirely different socio-economic environments of early 1990s UK and Czechoslovakia (and subsequently the Czech Republic), we may conclude that dietary patterns are relatively less susceptible to socio-economic trends and are probably much more conserved than originally expected. However, the reasons behind this are likely highly complex; a deeper understanding of the nature of this phenomenon thus requires further investigation.

Socio-economic transition generally indicates changes at the macro level and is expected to be a result of globalisation, urbanisation and industrialisation. It is expected that better improved economic situation status allows individuals to learn and live in safer and more friendly environments while achieving higher education levels[19]. Socio-economic changes are also inextricably linked to nutrition transition; however, this process has not been sufficiently documented. In a recent study which empirically examined the system of transitions using data from three countries (Indonesia, South Korea and the USA) at different stages of development, only vegetable oil consumption was found to have significantly increased in all three nations, with no particular significant trends established with respect to nutrition transition[20]. However, this publication assessed nutrition transition using either a percentage of energy obtained from carbohydrates, protein and fat[19] or based on a few items selected from FFQ: rice, sugar and sweeteners, vegetable oil, animal fat, milk and meat[20]. A study focusing on a society in transition was conducted in South Africa, evaluating the nutritional records of 5-year-old urban black South African children from 1984 to 1995[21]. The study revealed a robust shift towards a more 'western' diet: while the 1984 diet consisted of 30 % fat and 61 % carbohydrates, fat intake had increased to 41 % of total energy, while carbohydrate intake had decreased to 52 % in 1995. However, FFQ were only used for the evaluation of 1995 records, and the overall results are thus difficult to interpret.

In general, the effects of socio-economic transitions on nutritional determinants are vast, complex and far from adequately understood. No unifying trend capable of explaining the effects of socio-economic circumstances on food item choices and overall eating behaviour of populations or subpopulations has thus far been identified.

When analysing the influence of selected variables on dietary pattern distribution, we observed a strong influence of some investigated variables (maternal age, maternal education, substance abuse, maternal alcohol intake during pregnancy and maternal smoking during pregnancy) on pattern distribution, with the influence of maternal education and smoking most pronounced in the earlier time points after birth. This is unsurprising as plenty of evidence indicates that maternal education and smoking are important socio-economic parameters influencing dietary behaviour. In a study by Kiefte de Jong *et al.*, low paternal education, low household income, parental smoking, multiparity, maternal BMI, maternal carbohydrate intake and television watching of the child were determinants of a 'Western-like' diet equivalent to the 'junk food' pattern established in our study[22]. However, while Kiefte de Jong *et al.* primarily focused on toddlers, our study followed study individuals for a significantly longer period of time.

To conclude, this is the first study to identify the dietary patterns in a Central European population during a major socio-economic transition, thereby providing important information regarding the speed and quality of the dietary transition in this population.

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Availability of data and materials

The data that support the findings of this study are available from www.elspac.cz by Research Centre for Toxic Compounds in the Environment (RECETOX) but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Research Centre for Toxic Compounds in the Environment.

Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980020001056

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