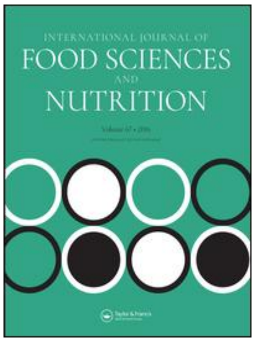

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RESEARCH ARTICLE

The cost of diets according to diet quality and sociodemographic characteristics in children and adolescents in Belgium

Camille Pedroni[a], Stefanie Vandevijvere[b], Lucille Desbouys[a], Manon Rouche[a] and Katia Castetbon[a]

[a]Research Centre in "Epidemiology, Biostatistics and Clinical Research", School of Public Health, Université libre de Bruxelles (ULB), Brussels, Belgium; [b]Scientific Institute of Public Health (Sciensano), Department of Epidemiology and Public Health, Unit "Lifestyle and chronic diseases", Brussels, Belgium

ABSTRACT

This study aims to estimate cost variations according to diet quality and sociodemographic characteristics in children. Data (n = 1,596; 5–17 y) from the *Belgian National Food Consumption Survey* were used. The "*Kidmed index*" and dietary patterns (DP) identified through principal component analysis were used to assess diet quality. Daily diet cost was estimated after linking the consumed foods with the *GfK ConsumerScan panel* food prices. The mean diet cost was 4.68€/day (SEM: 0.05). Adjusted for covariates and energy intake, the mean diet cost was 9.1% higher in the highest *Kidmed* adherence (*vs.* the lowest) and 6.2% higher in the tercile T3 (*vs.* T1) of the "Healthy" DP score. It was 4.8% lower in the T3 (*vs.* T1) for the "Junk food" DP score. Diet cost was higher in 12–17 year-olds (*vs.* 5–11 years) and in medium and high educated household (*vs.* the lowest). These findings support policies to make healthy diets more affordable.

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Diet cost; food price; diet quality; social inequalities; Kidmed index; principal component analysis

Introduction

Adopting a healthy diet at every stage of life helps stay healthy and prevent the risk of obesity and diet-related non-communicable diseases, which are the leading cause of morbidity and mortality in the world (Bennett et al. 2018). Children and adolescents require specific nutritional needs due to growth, puberty, psychomotor and intellectual development (Das et al. 2017). In most high-income countries such as Belgium, diet quality of children and adults follows a socio-economic gradient (Darmon and Drewnowski 2008; Giskes et al. 2010; Desbouys et al. 2019a; Desbouys et al. 2019b). Many studies have shown that people of higher socio-economic status (SES) are more likely to consume healthier diets, while lower-quality diets are more commonly observed in lower SES groups (Darmon and Drewnowski 2008; Giskes et al. 2010; Desbouys et al. 2019a; Desbouys et al. 2019b).

Among others, diet cost has been identified as one of the critical factors that may explain this social gradient (Aggarwal et al. 2011; Darmon and Drewnowski 2015). In the adult population, most of the studies, but not all (Lee et al. 2016), have found a positive association between the quality and the cost of diets (Schroder et al. 2006; Rehm et al. 2015; Tong et al. 2018). In 2013, a systematic review gathering a rather large set of observations concluded that healthier diets generally cost more than less healthy diets, though depending on whether the cost of the total diet or the cost per 2,000 kcal was estimated (Rao et al. 2013). Indeed, energy-dense foods are generally cheaper than nutrient-dense and energy-diluted foods, such as fruit and vegetables (Maillot et al. 2008; Drewnowski 2010). Therefore, food prices can represent a barrier to adopt nutrient-rich diets, particularly for low SES groups (Darmon and Drewnowski 2008). In addition to the food prices, a large set of other influences may also affect eating behaviours of children and adolescents such as individual taste, convenience, peer influence, food availability, parental monitoring, body image, medias and personal or cultural beliefs (Das et al. 2017).

Very few studies on diet cost have been undertaken in the child and adolescent population. To our knowledge, only three studies have been conducted in European countries: in Sweden among children aged 4, 8, 11 (Ryden and Hagfors 2011), in Germany among 4–18 year olds (Alexy et al. 2012; Alexy et al. 2014) and in Spain in 2–24 year olds (Schroder et al. 2016). As observed in adults, diets with higher

CONTACT Camille Pedroni camille.pedroni@ulb.be Université libre de Bruxelles, Route de Lennik, Brussels, Belgium
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nutritional quality scores were generally associated with a higher diet cost (Ryden and Hagfors 2011; Alexy et al. 2012; Alexy et al. 2014; Schroder et al. 2016). Two of those studies have also estimated diet cost variations according to the parental SES and reported higher diet cost when parental SES was higher (Ryden and Hagfors 2011; Schroder et al. 2016). Studies of food purchasing behaviours have shown that low SES groups were less likely to make healthy choices (Giskes et al. 2007) while high SES groups tended to have higher food expenditures and to make healthier choices (Pechey and Monsivais 2016). However, the three above mentioned studies contained some methodological limitations and need updating. Firstly, the analyses performed in the Spanish study (Schroder et al. 2016) are based on food consumption and price data collected 15 years ago. Secondly, for the two other studies, price data were collected for a limited time period (one month (Alexy et al. 2014) or one season (Ryden and Hagfors 2011) and therefore did not take into account yearly price variations. Moreover, a bias due to the difference of 7 years in the temporality between the food consumption and food prices data collection may have occurred in the Swedish study (Ryden and Hagfors 2011). Finally, few studies (Alexy et al. 2014; Schroder et al. 2016) analysed the role of sociodemographic characteristics other than SES, and none addressed their potential interaction with diet quality. Such an approach could have highlighted potential differences in the association between diet quality and cost according to the sociodemographic characteristics.

The small number of studies in the child and adolescent population and their limitations make it difficult to generalise the findings and to draw robust conclusions. In addition, it is important to explore these relationships in different countries because food prices and dietary habits differ (Slimani et al. 2002). Indeed, food prices are known to be, on the average, higher in Belgium in comparison with some other European countries such as France, Germany and Netherlands (Bruynoghe et al. 2018). The aim of this study was to estimate cost variations according to the overall nutritional quality of diets and to identify sociodemographic characteristics associated with the diet cost, among Belgian children and adolescents using nationally representative food consumption and prices data.

Materials and Methods

Data referred to diet nutritional quality of diets were retrieved from the 2014–2015 *Belgian National Food Consumption Survey* (BNFCS-2014), which is a national representative cross-sectional survey of the consumption habits of the population aged 3 to 64 years old residing in Belgium. The study was conducted in accordance with the ethical principles for medical research involving human participants (Declaration of Helsinki). The study protocol was approved by an Ethical Committee (University of Ghent, Belgian registration number: B670201319129) and the Commission for the Protection of Privacy. Written informed consent to participate in the study was obtained from all participants or parent(s)/legal guardian(s) of participants younger than 12 years old, before the start of the first home visit. The survey methodology (described in detail elsewhere (Bel et al. 2016)) followed the recommendations of *European Food Safety Authority* (EFSA) for the collection of food consumption data formulated in view of the EU-Menu project (EFSA 2014).

Sampling

Participants in the BNFCS-2014 were randomly selected from the National Population Register following a multistage stratified sampling procedure, including a geographical stratification based on the eleven provinces, a selection of municipalities within each province (proportionally to the size of each province), and a selection of individuals within each municipality (one or more groups of 50 individuals were randomly selected depending on the municipality size) (Bel et al. 2016). Data collection was equally planned over the four seasons and days of the week in order to incorporate seasonal effects and day-to-day variation in food intake.

The BNFCS-2014 sample included 3,297 participants aged from 3 to 64 years (Figure 1). Participants who failed to provide two 24 h dietary recalls (24 h-R) ($n = 151$) as well as those over the age of 17 ($n = 1{,}222$) were excluded from the sample of analysis here. Children under 5 years ($n = 271$) were also excluded, to keep school-aged children only. This led to a sample of 1,653 children and adolescents aged 5 to 17 years. Fifty-seven participants were further excluded from the sample due to missing data for diet quality assessment or covariates. Thus, the total study sample included 1,596 participants (Figure 1).

Measures

Dietary assessment

The methodology used to collect food consumption data in children (up to 9 years old) follows the

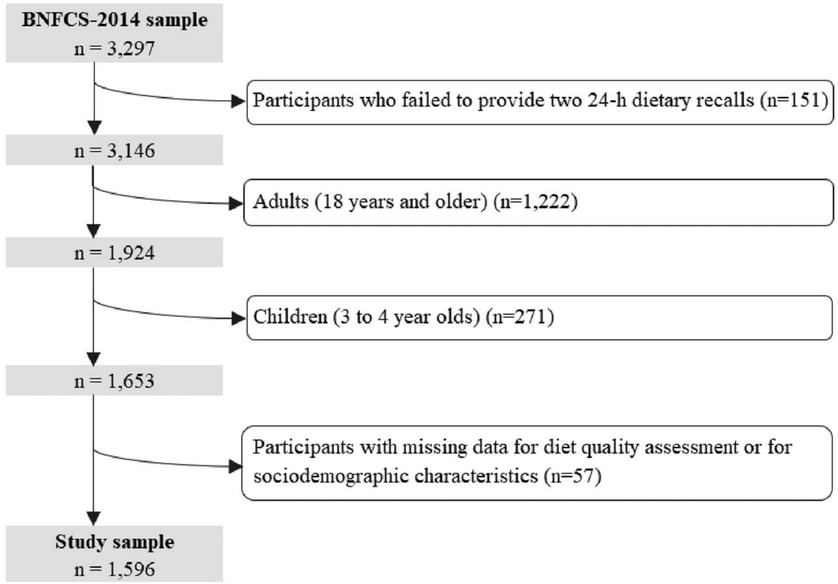

Figure 1. Inclusion diagram in the analyses. 2014 *Belgian National Food Consumption Survey*.

recommendations of the European PANCAKE project (Ocké et al. 2012). The parents or legal guardians were asked to complete, on two occasions, a one-day dietary diary listing all the food and drinks consumed by the child (Bel et al. 2016). On both occasions, the diary was followed by an interview using GloboDiet® software: the first was conducted by telephone during the interval between the two home visits and the second took place face-to-face during the second home visit of the investigator. The one-day food diaries had to be completed one or maximum two days before the completion interview with Globodiet® (Bel et al. 2016). A country-specific version of the Globodiet® software (formerly named EPIC-Soft) was used, ensuring the use of a standardised method and preventing the risk of systematic errors (Slimani et al. 2011; EFSA 2014). All food-diaries were open-ended (i.e., no pre-coded food lists) and special pages were available for home-made recipes and dietary supplement intake (Bel et al. 2016). In every booklet explanations and examples on how to fill in the diary were provided (Bel et al. 2016). This method was identified by the European PANCAKE project as the most suitable for collecting food consumption data in this age group (Ocké et al. 2012). For participants aged 10 or older, food consumption data were collected using two non-consecutive 24 h-R (EFSA 2014; Bel et al. 2016). Trained dietitians collected information from the participants through face-to-face interviews performed during the two home visits, with an interval of one to four weeks in order to account for within-subject variation (EFSA 2014; Bel et al. 2016). Portion sizes were estimated using household measurements, information from the manufacturer and a picture book adapted for the BNFCS-2014 (Bel et al. 2016). Food consumption data were linked with two food composition databases: NUBEL (NUBEL 2015) and NEVO (RIVM 2013). In addition, as recommended by the EFSA (EFSA 2014), a Food Frequency Questionnaire (FFQ) was completed by all the participants or proxy-respondent, reporting their usual frequency of consumption of specific foods and dietary supplements in the last 12 months (without specifying quantity) (Bel et al. 2016). During the first home visit interview, a paper FFQ was given to all participants or proxy-respondent. The FFQ for 10–17 and 18–64 year olds included 79 food items. In 3–9 year-old children, alcoholic beverages were removed, therefore, the FFQ comprised of 74 food items. The frequency response options for the food list were: "never", "less than once per month", "1–3 times per month", "once per week", "2–4 times per week", "5–6 times per week", "once per day", "2–3 times per day" and "more than 3 times per day". Participants were given a couple of weeks between the two home visits to complete the FFQ. It was retrieved by the investigator at the second home visit (Bel et al. 2016).

Food price data

Average food prices for the entire year 2014 data were received from Europanel based on the *GfK ConsumerScan panel* data (*GfK*, Brussels, Belgium). A stratified sampling strategy was applied by *GfK* considering household size and age of the main shopper. The sample included around 5,000 Belgian households. The panel members recorded household purchasing behaviours (and related shop-visiting behaviour) with respect to a broadly defined group of products regardless of the place of purchase. Participants were asked to record all their food purchases made each day during the survey year. They were provided with an electronic measuring device to record everything they bought (including fresh foods, packaged products), except meals at restaurants. This instrument consists of a preprogrammed hand terminal with a 4-line display, a simple keyboard and an integrated scanner for barcode scanning. Participants scanned the barcodes of all food products purchased or manually coded when the products did not have a barcode. The purchase and visit data recorded by the respondents were sent to the Research Centre via the Global System for Mobile Communications (GSM) network. For away-from-home meals, the costs of the ingredients were taken into account as no prices were available from *GfK*. Quality controls were conducted and households which failed to meet the minimum quality standards were excluded from the dataset (e.g., if participants did not provide food and price data on an ongoing basis).

A file with all foods and ingredients consumed by BNFCS-2014 participants was completed by *GfK* by assigning an average price for each food and ingredient listed. In addition, average prices were also available based on certain characteristics of foods (e.g., whole/half-skimmed/skimmed for milk, fresh/frozen/canned for fruits and vegetables, etc.). *ConsumerScan panel* data provided the prices of 70% of the foods included in the BNFCS-2014. A protocol was created to fill the missing prices, ensuring a systematic approach and traceability. For 15% of missing prices, the price of the most similar food (in terms of nutritional composition) was used within the same food group (e.g., price of white beans was assigned to red beans). For the remaining 15%, a conversion was needed. For example, the price of eggs was given per unit, so a conversion was made to obtain the price per kilogram. This file was then imported into the Stata® software (StataCorp 2019b) and linked with the BNFCS-2014 data. An average price was given to each food and ingredient listed in the food dairies, cited during the 24 h-R or included in FFQ according to the food characteristics specified. Edible and yield factors were taken into account to convert the prices from purchased foods to consumed foods.

Sociodemographic characteristics

Sociodemographic characteristics were collected in the BNFCS-2014 through a face-to-face questionnaire using a computer-assisted personal interviewing (CAPI) technique (Bel et al. 2016). In children aged 3–9, a parent or legal guardian was used as a proxy respondent (Bel et al. 2016). The sociodemographic characteristics included were sex, age (grouped into 5–11 years; 12–17 years), household type (single-parent; two-parent; other (e.g., intergenerational household)), highest education level in the household (secondary education or lower; short post-secondary education; long post-secondary education), country of birth (Belgium; other EU member state; outside EU) and region of residency (Flanders; Brussels; Wallonia).

Statistical analyses

Two complementary methodologies were used to assess diet quality: a priori and a posteriori method (Panagiotakos 2008).

A priori method

We used the *Kidmed index* which is based on principles sustaining Mediterranean dietary patterns as well as those that undermine it, and has been recognised as a reliable tool to evaluate children and adolescent dietary habits (Serra-Majem et al. 2004; Štefan et al. 2017). The score includes 16 items and ranges from −4 to 12 points (Serra-Majem et al. 2004). Items corresponding to favourable behaviours in relation to the Mediterranean diet were assigned a value of 1, while those concerning behaviours to be limited had a value of −1 (Serra-Majem et al. 2004). However, our score ranged from −3 to 12 points since no information regarding the item on the frequency of fast-food consumption was available. The construction of the score has been described in Supplemental Table 1. The FFQ was mainly used to compute the score but data from 24 h-R were used for four items (cereals or grains for breakfast, dairy products for breakfast, commercially baked foods or pastries for breakfast and cheese quantity per day). The total score was classified into three levels: ≤3, poor adherence ("very low diet quality"); 4–7, medium adherence ("improvement needed to adjust intake to Mediterranean patterns"); >8, high adherence ("optimal diet") (Serra-Majem et al. 2004).

A posteriori method

We conducted principal component analysis (PCA) to derive dietary patterns (DP) based on intakes (g/day) for 23 food groups (Hu 2002). Foods and beverages

Table 1. Energy-adjusted mean scores of *Kidmed index* and dietary patterns (DP), and diet cost according to the sociodemographic characteristics ($n = 1596$)[a]

		Diet quality score		Dietary pattern scores				Daily diet cost (€/day)	
	%	*Kidmed index* Mean (SEM)	p^b	DP1 – "Healthy" Mean (SEM)	p^b	DP 2 – "Junk food" Mean (SEM)	p^b	Mean (SEM)	p^b
Sex									
Boys	51.1	4.54 (0.11)	0.08	0.03 (0.05)	0.82	−0.00 (0.05)	0.79	4.70 (0.04)	0.60
Girls	48.9	4.81 (0.10)		0.01 (0.05)		0.01 (0.05)		4.66 (0.04)	
Age									
5–11 years	57.0	5.15 (0.09)*	<0.001	−0.01 (0.06)	0.38	0.00 (0.05)	0.98	4.62 (0.04)*	0.03
12–17 years	43.0	4.13 (0.11)		0.06 (0.04)		0.00 (0.06)		4.75 (0.04)	
Household type									
Single-parent	12.3	4.39 (0.24)	0.002	0.17 (0.09)	0.046	0.04 (0.09)	0.45	4.75 (0.08)	0.24
Two-parent	75.0	4.82 (0.08)		0.02 (0.04)		−0.02 (0.04)		4.69 (0.04)	
Other	12.7	4.07 (0.21)*		−0.13 (0.08)*		0.14 (0.13)		4.56 (0.08)	
Highest education level in the household									
Low	38.5	4.32 (0.13)*	<0.001	−0.10 (0.05)*	0.007	0.23 (0.06)*	<0.001	4.52 (0.05)*	<0.001
Medium	32.2	4.78 (0.13)		0.03 (0.06)		0.02 (0.07)		4.69 (0.06)	
High	29.3	5.03 (0.12)		0.18 (0.08)		−0.32 (0.06		4.87 (0.05)	
Country of birth									
Belgium	93.6	4.61(0.08)*	0.001	−0.00 (0.04)*	0.01	0.02 (0.04)*	0.006	4.68 (0.03)	0.99
Other EU member state	3.6	5.42 (0.34)		0.44 (0.16)		−0.35 (0.12)		4.68 (0.15)	
Outside the EU	2.8	5.93 (0.43)		0.32 (0.20)		−0.30 (0.20)		4.69 (0.15)	
Region of residency									
Flanders	57.7	4.74 (0.10)	<0.001	0.15 (0.04)	<0.001	(0.05)	0.007	4.71 (0.04)	0.02
Brussels	9.8	5.53 (0.25)		0.24 (0.20)		−0.32 (0.11)		4.86 (0.12)	
Wallonia	32.6	4.30 (0.12)*		−0.28 (0.05)*		0.08 (0.06)*		4.57 (0.05)*	

2014 *Belgian National Food Consumption Survey*.
[a]All analyses were weighted and adjusted for total energy intake; [b]*p*-value of the Wald test; *Reference group; bold: category for which the mean statistically differed from the reference category. SEM: Standard error of the mean.

included in each food groups are presented in Supplemental Table 2. We applied a varimax rotation to achieve a simpler structure with uncorrelated factors to ease the interpretation (Kaiser 1958). The number of factors to retain in the analysis was determined using eigenvalues of each factor and Cattel's scree test (plot of the total variance explained by each factor) (Cattell 1966). Food groups with a factor loading higher than an absolute value of 0.2 were considered as significant contributors to the DP, which have been labelled accordingly. For each participant, we estimated a factor score for each of the DPs identified by summing the observed intakes of the 23 foods groups, weighted by their factor loading. A higher score indicates a stronger adherence to the DP. We then divided participants into terciles of each DP score.

For both 24 h-R days, the sum of the prices of all foods and non-alcoholic beverages consumed was computed and then divided by two in order to obtain a mean daily diet cost (€/day). All estimates presented, including diet costs, were adjusted for total energy intake. It is generally considered as more appropriate to compare the price of energy-adjusted diets or for isoenergetic diets (e.g., 2,000 kcal) (Darmon and Drewnowski 2015) given that total energy intake may be associated with diet cost and exposure variables and thus act as a confounding variable (Willett et al. 1997).

Since the Black method (Black 2000) does not take into account energy needs related to growth, under-reports were identified as those declaring mean energy intake below two standard deviations of the mean energy intake of the sample. Under-reporters ($n = 5$) were kept in the study sample (EFSA 2014).

An individual weighting factor was calculated according to sex, age, province of residency, season and day of the first 24 h-R (i.e., week vs. weekend) to ensure the estimations to be representative to the population living in Belgium. All analyses included the weighting factors and the survey design (using the "svyset" function, Stata®) (StataCorp 2019a,b).

Energy-adjusted linear regression analyses were conducted to estimate the associations of sociodemographic characteristics with the diet quality scores (*Kidmed index* and DP scores) on one hand, and with the diet cost (€/day) on the other hand. In addition, mean daily consumption of food groups was calculated according to the terciles of diet cost. In order to assess diet cost variations according to the diet quality (as continuous scores or categories based on terciles), energy-adjusted linear regression analyses and then multivariable linear regression modelling adjusted for covariates (total energy intake, sex, age, household type, household education level, country of birth and region) were undertaken. Adjusted means of diet cost were post-estimated using predictive margins, with covariates being treated as non-fixed (Williams RA

Table 2. Energy adjusted daily consumption means (SEM; in g/d) of food groups according to the terciles of diet cost and contribution (%) of food groups to the total daily diet cost ($n = 1{,}596$).

	Daily diet cost (€/day)					
Median (min.-max.)	T1 3.28€ (0.97–3.81)	T2 4.36€ (43.81–4.98)	T3 5.88€ (4.98–14.39)	p^a	Contribution (%) to the total daily diet cost (€/day)	
Fruits & vegetables						
Vegetables	85.14 (3.85)*	102.45 (3.21)	131.32 (4.83)	<0.001	13.3%	5.8%
Fruit	110.50 (7.95)*	141.23 (6.78)	205.73 (10.33)	<0.001		7.5%
Potatoes & cereal products						
Potatoes & refined cereal products	176.77 (4.84)	176.04 (4.00)	170.43 (4.79)	0.64	13.9%	10.5%
Whole-grain cereal products	43.17 (4.54)	34.28 (2.46)	37.79 (3.44)	0.10		2.5%
Processed breakfast cereals	8.20 (0.90)	7.04 (0.76)	6.70 (0.89)	0.45		0.9%
Non-processed breakfast cereals	0.35 (0.18)	0.56 (0.18)	1.02 (0.24)	0.10		0.0%
Protein-driving products						
Nuts & seeds	0.78 (0.26)*	1.99 (0.34)	2.86 (0.44)	<0.001	36.9%	0.4%
Legumes	2.11 (0.86)	1.37 (0.35)	3.71 (1.46)	0.22		0.2%
Eggs	8.19 (1.06)	8.34 (0.97)	8.18 (1.24)	0.99		0.7%
Fish & seafood	0.90 (1.39)*	10.69 (1.21)	30.06 (2.85)	<0.001		4.6%
Poultry, meat & processed meat	89.81 (3.41)*	94.93 (2.54)	107.48 (3.76)	0.007		20.2%
Milk, yoghurt & fresh cheese	221.55 (13.37)*	201.39 (8.96)	167.91 (10.06)	0.02		6.0%
Cheese & cream	20.34 (1.68)	23.42 (1.18)	26.06 (1.78)	0.12		4.3%
Substitutes	6.61 (2.43)	6.64 (1.56)	16.03 (3.79)	0.08		0.5%
Added fat, sweets & salty snacks						
Vegetable fats	8.55 (0.57)	7.30 (0.44)	7.20 (0.52)	0.15	22.0%	0.6%
Animal fats	2.02 (0.39)	2.03 (0.26)	1.46 (0.23)	0.31		0.3%
Fatty sauces	9.67 (1.19)*	13.09 (.097)	18.20 (2.08)	0.005		1.8%
Salty snacks rich in fats	12.93 (1.47)*	10.61 (1.61)	6.58 (1.18)	0.009		1.3%
Sugar & sugar confectionery	14.25 (1.18)	13.53 (0.83)	13.43 (1.20)	0.86		2.5%
Sweet spreads & sauces	31.00 (2.29)*	27.92 (1.52)	16.51 (1.66)	<0.001		2.5%
Biscuits, cakes, desserts & ice-creams	59.91 (3.14)*	78.90 (2.88)	89.22 (3.72)	<0.001		13.0%
Non-alcoholic beverages						
Low to non-caloric beverages	654.06 (27.07)*	701.60 (25.38)	798.14 (25.58)	0.005	10.7%	4.0%
Sugar-sweetened beverages	212.24 (14.39)	244.31 (12.30)	262.48 (17.92)	0.09		6.7%

2014 *Belgian National Food Consumption Survey*. All analyses were weighted and adjusted for total energy intake; [a]Wald test; *Reference group; bold: category for which the mean statistically differed from the reference category ($p < 0.05$). SEM: Standard error of the mean.

2012). Interactions between diet quality scores and sociodemographic characteristics were tested ($p < 0.05$) one by one in three models: without adjustment, with adjustment for total energy intake and in models adjusted for total energy intake and covariates.

The normality of the diet cost distribution was verified on the basis of a histogram. Homoscedasticity was tested using the Levene test. The outliers were retained in the analyses given the plausibility of values. For multivariable models, normality, homoscedasticity, and linearity of the residuals, along with the absence of co-linearity between variables were graphically verified in unweighted models. Statistical significance threshold was set at $p < 0.05$. All analyses were performed using Stata® version 16 (StataCorp, College Station, TX, USA) (StataCorp 2019b).

Results

Sample characteristics are described in Table 1. The mean total diet cost without alcohol was 4.68€/day (Standard Error of the Mean, SEM: 0.05). Children and adolescents were classified into the *Kidmed index* categories as follows: 34.1% with poor adherence, 52.1% with medium adherence and 13.8% with high adherence. We identified two major DPs that explained 12.7% of the total variance. These two patterns were labelled as “Healthy” (DP1) and “Junk food” (DP2) (Figure 2). Indeed, DP1 was characterised by high intake (factor loadings $\geq$0.20) in vegetable fat, vegetables, legumes, low to non-caloric beverages, whole-grain cereal products, and fish and seafood, whereas DP2 was rich in sugar-sweetened beverages, salty snacks and fatty sauces and poor (factor loadings ≤ -0.20) in low to non-caloric beverages and fruits (Figure 2). Mean daily consumption in these food groups are described according to the terciles of each DP (Supplemental Table 3).

Nutritional quality of diets according to sociodemographic characteristics

No difference was observed in both *Kidmed index* and DP scores between boys and girls (Table 1). Mean of *Kidmed index* was higher in the 5–11 years group (*vs.* 12–17 years), yet the two DP scores were not statistically associated with age categories. The mean *Kidmed index* was higher in two-parent families in comparison with “other” household types (e.g., intergenerational household). Mean “healthy” DP score was higher in single-parent families (*vs.* “other”), while “Junk food” DP score was not associated with household type.

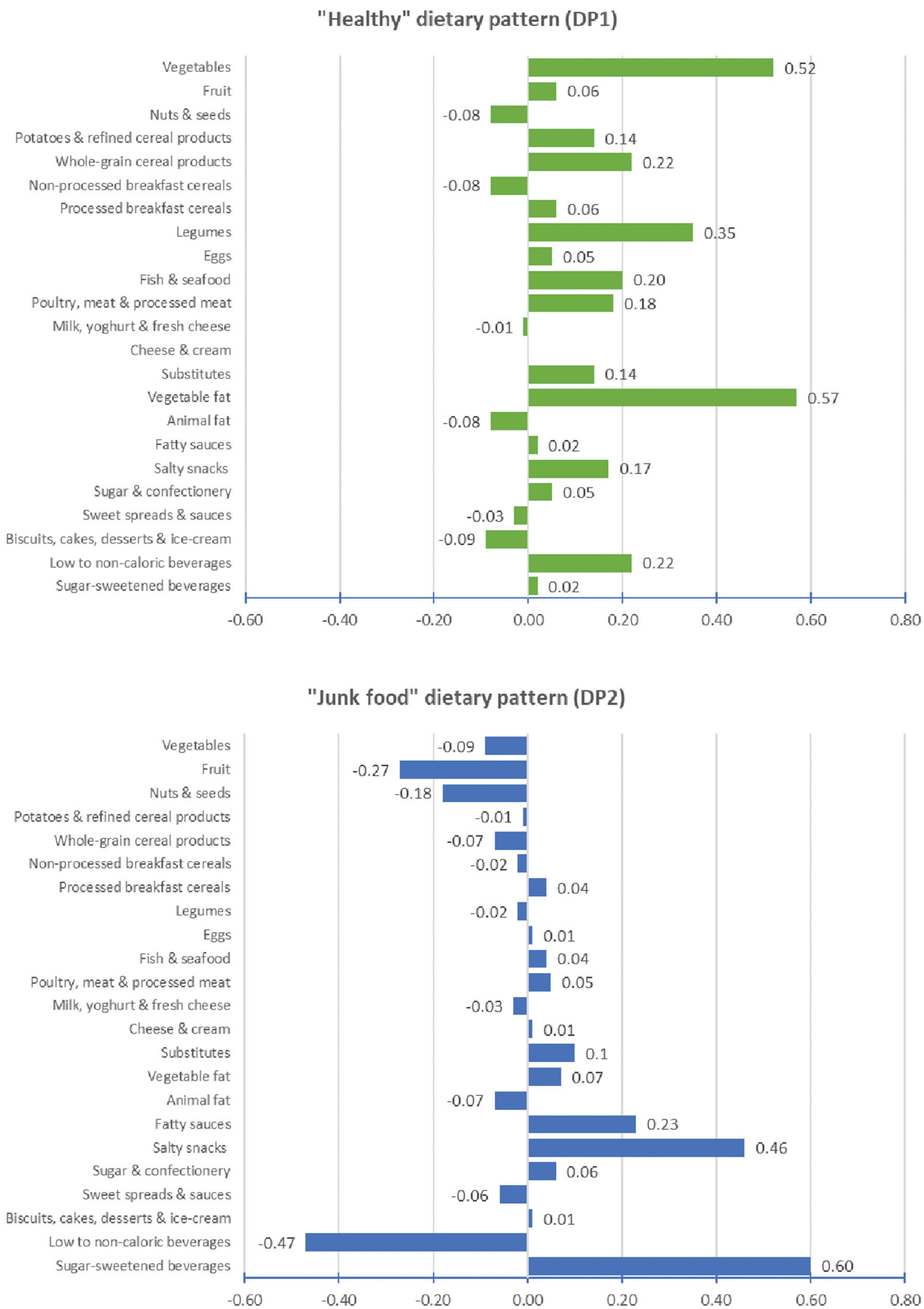

Figure 2. Dietary patterns (DP). Factor loadings for the two dietary patterns derived from 23 food groups.

Higher household education level and being born abroad were both associated with more favourable diet quality based on the *Kidmed index* and the two DP scores. Lastly, means of *Kidmed index* and "Healthy" DP score were higher in Flanders and Brussels in comparison with Wallonia, whereas mean "Junk food" DP score was lower in Brussels than in Wallonia (Table 1).

Table 3. Multivariable linear regression analyses estimating daily diet cost variations according to *Kidmed index* and dietary pattern (DP) scores ($n = 1{,}596$)[a].

	Daily diet cost (€/day)							
	Adjusted for total energy intake				Adjusted for total energy intake and covariates[b]			
	R^2 (%)	Mean (SEM)	β (95% CI)	*p*	R^2 (%)	Mean (SEM)	β (95% CI)	*p*
Kidmed index								
For 1-point increase	59.0		0.06 (0.04 – 0.09)	<0.001	60.4		0.07 (0.04 – 0.09)	<0.001
Categories	58.7			<0.001	60.0			<0.001
Poor adherence		4.50 (0.04)*	Ref.			4.50 (0.06)*	Ref.	
Medium adherence		4.74 (0.04)	0.24 (0.11 – 0.36)			4.73 (0.06)	0.23 (0.11 – 0.36)	
High adherence		4.90 (0.10)	0.40 (0.18 – 0.61)			4.91 (0.10)	0.40 (0.20- 0.61)	
"Healthy" DP								
For 1-point increase	59.1		0.14 (0.07 – 0.21)	<0.001	60.2		0.12 (0.06 – 0.19)	<0.001
Terciles	58.6			<0.001	59.8			0.001
T1		4.50 (0.04)*	Ref.			4.54 (0.06)*	Ref.	
T2		4.67 (0.06)	0.17 (0.03 – 0.31)			4.67 (0.07)	0.14 (-0.00 – 0.28)	
T3		4.85 (0.06)	0.34 (0.19 – 0.49)			4.82 (0.06)	0.28 (0.13 – 0.43)	
"Junk food" DP								
For 1-point increase	58.4		−0.10 (−0.15 - −0.04)	0.001	59.6		−0.08 (-0.13 - −0.02)	0.005
Terciles	58.5			<0.001	59.7			0.004
T1		4.81 (0.05)*	Ref.			4.78 (0.06)*	Ref.	
T2		4.72 (0.06)	−0.09 (-0.24 – 0.06)			4.71 (0.07)	−0.07 (-0.22 – 0.08)	
T3		4.51 (0.05)	−0.30 (-0.45 - −0.16)			4.55 (0.06)	−0.23 (-0.37 - −0.09)	

2014 *Belgian National Food Consumption Survey*. [a]All analyses were weighted; [b]Sex, age, household type, household education level, country of birth and region; *Reference group; bold: category for which the mean statistically differed from the reference category ($p < 0.05$)

Cost of diets according to the sociodemographic characteristics

Independently of energy intake, daily diet cost was significantly higher in the 12–17 years group (*vs.* 5–11 years), in medium and high household education level (*vs.* the lowest) and in Flanders and Brussels (*vs.* Wallonia) (Table 1). No association was found between diet cost and sex, household type and country of birth (Table 1).

Food and beverage intakes according to the terciles of diet cost

Compared with the lowest cost tercile (T1), intake of vegetables, fruit, nuts and seeds, fish and seafood, fatty sauces, non-caloric beverages, the group of poultry, meat and processed meat and the group of biscuits, cakes, desserts and ice cream was significantly higher in the highest tercile of diet cost (T3), while intake of salty snacks rich in fats, sweet spreads and sauces, and "milk, yoghurt and fresh cheese" was significantly lower (Table 2). The protein-based product group (36.9%) was the most important contributor to the total daily diet cost, followed by added fat and sugar (22.0%), potatoes and cereal products (13.5%), fruit and vegetables (13.4%), and non-alcoholic beverages (10.7%) (Table 2).

Diet cost variations according to the nutritional quality of diets

The cost of diet significantly increased with the overall diet quality assessed by the scores as continuous or in categories (Table 3). Indeed, in comparison with the lowest category, diet cost was significantly higher in the intermediate and highest categories for both *Kidmed index* and "Healthy" DP score, whereas the mean diet cost was lower in T3 of "Junk food" DP score than in T1. Adjusted for energy intake and covariates, the difference in mean diet cost between the lowest and the highest category of adherence to *Kidmed index* was 9.1% (0.41€/day). Similarly, the mean diet cost of T3 of the "Healthy" pattern score was 6.2% (0.28€/day) higher in comparison with T1 and was 4.8% (0.23€/day) lower in T3 than in T1 for the "Junk food" pattern score. When considering the scores in continuous form, for each one-point increase of diet quality scores, the cost increased by 0.07€for the *Kidmed index* and by 0.12€ for the "Healthy" DP score, and decreased by 0.08€for the "Junk food" DP score. The cost difference was 1.12€/day between the minimum and the maximum *Kidmed index*. Results were similar whether or not the models were adjusted for covariates (Table 3). In addition, no statistical interaction between sociodemographic characteristics and diet quality was found in the relationship with the cost of diets.

Discussion

Since most studies on diet cost have previously been conducted in the adult population, we considered it interesting to study this topic in youth. Since these two populations are different in many ways (nutritional needs, eating habits, food preferences, food choice independency, etc.), we wanted to explore this issue among younger populations to determine whether the same conclusions could be made. In addition, our aim was to estimate cost variations across sociodemographic categories in children and adolescents, an even more under-addressed issue. As observed among adults in many countries, we found that diet quality was positively associated with diet cost. In addition, diet cost was higher in adolescents compared with children independently of energy intake, in medium and higher household education level (*vs*. the lowest) and was subject to regional variations.

Unlike the three previous studies conducted in youth (Ryden and Hagfors 2011; Alexy et al. 2012; Alexy et al. 2014; Schroder et al. 2016) and most of the studies carried out in adults (Rao et al. 2013), we chose to address the issue of diet quality using a mixed methodology. The combination of "a priori" and "a posteriori" methods allows to provide a richer description of the population's eating patterns and to determine whether different methods would lead to consistent conclusions regardless of the method used to assess diet quality. Overall, our findings confirmed this hypothesis. Indeed, they showed that the quality of diets was positively associated with their cost independently of the method used for the diet quality assessment. Similarly, associations between sociodemographic characteristics and dietary quality were overall similar whether nutritional quality scores or DP scores were used. Nevertheless, differences were observed regarding the presence of statistically significant associations (this was the case for age) or in the strength of the associations. This finding may be explained by the weak correlation between the Kidmed index and PDs (Cramer's *V*-test <0.15), as these tools do not assess diet quality according to the same criteria.

The magnitude in the cost differences we observed between less and healthier diets was close to those found in the other three studies in youth (Ryden and Hagfors 2011; Alexy et al. 2014; Schroder et al. 2016). In comparison with our findings, the German study found an energy-adjusted cost difference for each 1-point increase of 0.05€ based on the *Healthy Nutrition Score for Kids and Youth* (HuSKY) and of 0.18€based on the *Nutrient Quality Index* (NQI) (Alexy et al. 2014). The Spanish study which used the *Kidmed Index*, found a cost difference between the lowest (0 to 3 points) and the highest adherence (>7 points) level of 0.71€/day and 0.28€/1,000 kcal (Schroder et al. 2016). Overall, we found that participants in the highest cost tercile had a healthier dietary profile, with a higher consumption of healthy foods such as fruits and vegetables and lower consumption of unhealthy foods such as salty snacks and sweet spreads. The fact that foods rich in vitamins and minerals are generally more expensive than foods rich in sugars and fats (Maillot et al. 2008; Drewnowski 2010), and the amount of intake within more expensive food groups contribute to explain why healthier diets cost more.

Our analyses showed that both quality and cost of diets were positively associated with the household education level confirming an observation widely reported in the literature among both adults (Darmon and Drewnowski 2008; Rehm et al. 2011; Tong et al. 2018) and youth (Ryden and Hagfors 2011; Schroder et al. 2016; Desbouys et al. 2019b). The energy-adjusted cost difference between the lowest and the highest household education level (0.35€/day i.e., 0.21€/1,000 kcal) found in our study was slightly higher than that observed in Sweden (0.17€/1,000 kcal) (Ryden and Hagfors 2011) and in Spain (0.13€/1,000 kcal) (Schroder et al. 2016). It is noteworthy that those estimations are based on prices data collected in 2010 for the Swedish study (Ryden and Hagfors 2011) and in 2000 for the Spanish study (Schroder et al. 2016). The diets of children and adolescents are still highly dependent on the food their parents buy and the meals they prepare. It can therefore be assumed that the observations made in low SES adults could be transposed to the younger population, with a similar social gradient found in the quality and cost of diets for both adults and youth.

Studies in adults have suggested that the reasons why people with lower SES have poorer quality diets may be related to the fact that they are mainly guided in their food purchasing by food price and familiarity (what is usually consumed), whereas health considerations would be the priority for people with high SES (Konttinen et al. 2013). Indeed, energy-dense foods, in addition to being generally cheaper (Maillot et al. 2008; Drewnowski 2010), are often more palatable (Drewnowski 1998; Gibson 2006), and have certain psychosocial properties (Gibson 2006; Hemmingsson 2014) that may explain why they are more likely to be consumed by low SES individuals. Moreover, the price of healthy food is often perceived as an important barrier by low-income households (Reicks et al. 1994; Mackenbach et al. 2015). Adult studies (Durand-Gasselin and Luquet 2000) as well as a recent study including children aged 5, 8 and 11 years (Moraeus et al. 2020), showed that participants from households with lower education level had less varied diet. This finding contributes to explain why their diets are often poorer in nutrients, less diversified, and generally cheaper in low SES households.

Several studies conducted among adults (Aggarwal et al. 2011; Tong et al. 2018), including a Belgian paper using the same data as for the analyses here (Pedroni et al. 2021), have found a non-significant or weaker association between the quality and cost of diets among adults with higher SES. Such findings suggests that for low SES people, adopting a healthier diet leads to a significant diet cost difference, whereas for people with higher SES, diet cost does not vary significantly whether they eat healthily or not. We therefore expected to potentially find this interaction also in youth, but it was not observed (the three previous studies in youth did not test interactions). This absence of interaction would mean that for children and adolescents, adopting healthier eating habits would lead to higher dietary costs regardless of their SES. The lack of interaction could also be explained by the criteria used to assess the diet quality here or by a lack of statistical power. Further investigations on this topic is therefore needed because it could have consequences on health promotion messages. Furthermore, even if the cost difference we observed between education levels seems relatively small, determining whether low SES Belgian households have sufficient financial resources to be able to afford the necessary cost difference to achieve a healthier diet still needs to be evaluated.

We found that diet quality was lower in adolescents aged 12–17 years than in the children aged 5–11 years. Another study conducted in the same Belgian population has shown that the 14–17 year-old age group was the most deviant from food-based dietary guidelines (Bel et al. 2019). In contrast, diet cost was higher in this adolescent group than in the children group. This finding is comparable to the two studies in youth in Spain (Schroder et al. 2016) and Germany (Alexy et al. 2014) where the cost per day, as well as the energy-adjusted cost per day, increased with age. Knowing that the cost of diets tends to increase with the diet quality, it was quite surprising that they trend in the opposite direction with age. One explanation may lie in the food choices made by adolescents. Adolescents may eat unhealthier foods than children, with those that are relatively expensive in larger quantities, such as meat and sugar-sweetened beverages. This hypothesis would require further investigation.

In our study, sex was not associated with either the quality or cost of diets. We compared the mean *Kidmed Index* between boys and girls in the two age groups separately (data not shown). In children, girls' diets were of significantly higher quality, whereas in adolescents, the means were not statistically different according to sex. This finding contrasts with previous studies which showed that adolescent girls (del Mar Bibiloni et al. 2012; de Oliveira Figueiredo RA et al. 2019; Kelly et al. 2019) and women (Schroder et al. 2006; Rehm et al. 2015; Tong et al. 2018) tended to show higher quality diets. However, in our sample, no difference in cost between 5–11 year-old boys and girls was found, meaning that higher quality diets in girls did not translate into a higher diet cost. Only one study explored such an association in youth and concluded that the daily diet cost (€/day) was higher in boys but that the energy-adjusted cost (€/1,000 kcal) was higher in girls (Schroder et al. 2016). Thus, whether the difference in diet quality between girls and boys would lead to a varying cost requires confirmation among larger samples of adolescents.

One strength of this study lies in its methodology. First, consumption data for the BNFCS-2014 was collected following guidelines developed by the EFSA to harmonise food consumption surveillance in Europe (EFSA 2014). In addition, the analyses accounted for the survey design and individual weighting factors, enabling the estimates to be considered as representative of the population living in Belgium. Price data were collected during the same period as the consumption data and were detailed according to their presentation (i.e., fresh, frozen or canned/glass for fruits and vegetables). Moreover, the collection of food consumption data as well as food price data was spread over several months in order to take seasonal variations into account. Since both diet quality and diet cost were derived from two independent sources, the possibility that some level of association might be artefactual can be ruled out. Finally, unlike most papers on this topic, we chose to use a mixed methodology in our analyses of diet quality, which consolidated our conclusion.

However, some limitations about the data used in our study are worth noting. For instance, for the *Kidmed Index*, the definition of food groups are relatively outdated (i.e., there is no differentiation between wholegrain vs. refined grain) (Fulgoni et al. 2018) and ultra-processed food products are not accounted for (Monteiro et al. 2013). In addition, because the food cost and consumption data came from two different sources, the prices of foods actually purchased by the BNFCS-2014 participants were not known, nor were the exact nutritional composition of the foods purchased by the *GfK ConsumerScan* panel. Furthermore, seasonal or other sources of variation in prices could not be taken into account. Finally, the prices of away-from-home meals were not available, but the prices of the ingredients were taken into account instead.

Recall bias and social desirability bias leading to under- or over-estimation of intakes were also possible in the 24 h-R and FFQ (Althubaiti 2016). Child and adolescent's dietary assessment carries some specific limitations (Livingstone et al. 2004; Magarey et al. 2011). Indeed, using a parent as a proxy-respondent may lead to an underestimation of intakes: while parents may reliably report their child's food intake at home (Eck et al. 1987; Baranowski et al. 1991; Livingstone et al. 2004) they do not really know what he/she consumes outside of the home (Baranowski et al. 1991; Livingstone et al. 2004). In addition, it seems that children and adolescents may have difficulties accurately quantifying their intakes and portion sizes (Livingstone et al. 2004; Magarey et al. 2011). However, the use of picture book and household measurement tools to report portions sizes can improve the accuracy of the reported intakes (Livingstone et al. 2004; Magarey et al. 2011).

Conclusion

Higher quality diets were associated with higher diet costs in children and adolescents in Belgium. A social gradient was observed for both the quality and cost of diets, consistently with previous reports. This topic was insufficiently addressed so far, and further studies are still needed to better understand the mechanisms and social disparities related to the cost of diets for younger people. For instance, why adolescents' diets cost more than those of children while it is of poorer quality needs to be clarified. In addition, studies based on linear programming would also be useful to identify the components of healthy diets at the most affordable cost in Belgium. Overall, our findings contribute to a better understanding of social inequalities in the children and adolescents' diets and may help policymakers to develop public health policies to improve diets and reduce such inequalities.

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Ethics approval and consent to participate

The study was conducted in accordance with the ethical principles for medical research involving human subjects (Declaration of Helsinki) and was approved by the Ethical Committee of the University of Ghent (Reference: 2013/1025) (Belgian Registration number: B670201319129). Written informed consent to participate in the study was obtained from all participants. The manuscript does not contain clinical studies or patient data.

Disclosure statement

The authors declare that they have no conflict of interest.

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Data availability statement

The datasets generated and analysed in this study are not available to the public, due to the law on the protection of privacy regarding to the processing of personal data. Therefore, these data can only be made available to third parties under certain conditions.

References

Aggarwal A, Monsivais P, Cook AJ, Drewnowski A. 2011. Does diet cost mediate the relation between socioeconomic position and diet quality? Eur J Clin Nutr. 65(9):1059–1066.

Alexy U, Bolzenius K, Köpper A, Clausen K, Kersting M. 2012. Diet costs and energy density in the diet of German children and adolescents. Eur J Clin Nutr. 66(12):1362–1363.

Alexy U, Schwager V, Kersting M. 2014. Diet quality and diet costs in German children and adolescents. Eur J Clin Nutr. 68(10):1175–1176.

Althubaiti A. 2016. Information bias in health research: definition, pitfalls, and adjustment methods. J Multidiscip Healthc. 9:211–217.

Baranowski T, Sprague D, Baranowski JH, Harrison JA. 1991. Accuracy of maternal dietary recall for preschool children. J Am Diet Assoc. 91(6):669–674.

Bel S, De Ridder KAA, Lebacq T, Ost C, Teppers E, Cuypers K, Tafforeau J. 2019. Habitual food consumption of the Belgian population in 2014-2015 and adherence to food-based dietary guidelines. Arch Public Health. 77:14.

Bel S, Van den Abeele S, Lebacq T, Ost C, Brocatus L, Stiévenart C, Teppers E, Tafforeau J, Cuypers K. 2016.

Protocol of the Belgian food consumption survey 2014: objectives, design and methods. Arch Public Health. 74: 20.

Bennett JE, Stevens GA, Mathers CD, Bonita R, Rehm J, Kruk ME, Riley LM, Dain K, Kengne AP, Chalkidou K, et al. 2018. NCD Countdown 2030: worldwide trends in non-communicable disease mortality and progress towards sustainable development goal target 3.4. Lancet. 392(10152):1072–1088.

del Mar Bibiloni M, Martínez E, Llull R, Pons A, Tur JA. 2012. Western and Mediterranean dietary patterns among Balearic Islands' adolescents: socio-economic and lifestyle determinants. Public Health Nutr. 15(4):683–692.

Black A. 2000. Critical evaluation of energy intake using the Goldberg cut-off for energy intake: basal metabolic rate. A practical guide to its calculation, use and limitations. Int J Obes Relat Metab Disord. 24(9):1119–1130.

Bruynoghe C, Claessens M, Ingelbrecht M, et al. 2018., Analyse des prix, rapport annuel 2017 de l'institut des comptes nationaux. https://economie.fgov.be/fr/publicaties/analyse-des-prix-2017-icn-2.

Cattell R. 1966. The scree test for the number of factors. Multivariate Behav Res. 1(2):245–276.

Darmon N, Drewnowski A. 2008. Does social class predict diet quality? Am J Clin Nutr. 87(5):1107–1117.

Darmon N, Drewnowski A. 2015. Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis. Nutr Rev. 73(10):643–660.

Das JK, Salam RA, Thornburg KL, Prentice AM, Campisi S, Lassi ZS, Koletzko B, Bhutta ZA. 2017. Nutrition in adolescents: physiology, metabolism, and nutritional needs. Ann N Y Acad Sci. 1393(1):21–33.

de Oliveira Figueiredo RA, Viljakainen J, Viljakainen H, Roos E, Rounge TB, Weiderpass E. 2019. Identifying eating habits in Finnish children: a cross-sectional study. BMC Public Health. 19(1):312.

Desbouys L, De Ridder K, Rouche M, et al. 2019a. Food consumption in adolescents and young adults: age-specific socio-economic and cultural disparities (Belgian food consumption survey 2014). Nutrients. 11:1520.

Desbouys L, Mejean C, De Henauw S, et al. 2019b. Socio-economic and cultural disparities in diet among adolescents and young adults: a systematic review. Public Health Nutr. 23(5):843–860.

Drewnowski A. 1998. Energy density, palatability, and satiety: implications for weight control. Nutr Rev. 56(12): 347–353.

Drewnowski A. 2010. The cost of US foods as related to their nutritive value. Am J Clin Nutr. 92(5):1181–1188.

Durand-Gasselin S, Luquet F. 2000. La vie quotidienne autour de l'alimentation. Les modes de vie, les représentations socio-culturelles et les comportements alimentaires de 55 familles à faibles revenus en banlieue parisienne. Med Nutr. 1:40–52.

Eck L, Klesges R, Hanson C. 1987. Recall of a child's intake from one meal; are parents accurate? J Am Diet Assoc. 89:784–789.

EFSA, 2014. Guidance on the EU Menu methodology. Efsa J. 12:S58.

Fulgoni V, Wallace T, Stylianou K, et al. 2018. Calculating intake of dietary risk components used in the global burden of disease studies from what we eat in America/national health and nutrition examination surveys. Nutrients. 10(10):1441.

Gibson E. 2006. Emotional influences on food choice: sensory, physiological and psychological pathways. Physiol Behav. 89(1):53–61.

Giskes K, Avendano M, Brug J, Kunst AE. 2010. A systematic review of studies on socioeconomic inequalities in dietary intakes associated with weight gain and overweight/obesity conducted among European adults. Obes Rev. 11(6):413–429.

Giskes K, Van Lenthe FJ, Brug J, Mackenbach JP, Turrell G. 2007. Socioeconomic inequalities in food purchasing: the contribution of respondent-perceived and actual (objectively measured) price and availability of foods. Prev Med. 45(1):41–48.

Hemmingsson E. 2014. A new model of the role of psychological and emotional distress in promoting obesity: conceptual review with implications for treatment and prevention. Obes Rev. 15(9):769–779.

Hu F. 2002. Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol. 13(1):3–9.

Kaiser H. 1958. The varimax criterion for analytic rotation in factor analysis. Psychometrika. 23(3):187–200.

Kelly C, Callaghan M, Molcho M, Nic Gabhainn S, Alforque Thomas A. 2019. Food environments in and around post-primary schools in Ireland: associations with youth dietary habits. Appetite. 132:182–189.

Konttinen H, Sarlio-Lähteenkorva S, Silventoinen K, Männistö S, Haukkala A. 2013. Socio-economic disparities in the consumption of vegetables, fruit and energy-dense foods: the role of motive priorities. Public Health Nutr. 16(5):873–882.

Lee AJ, Kane S, Ramsey R, Good E, Dick M. 2016. Testing the price and affordability of healthy and current (unhealthy) diets and the potential impacts of policy change in Australia. BMC Public Health. 16:315.

Livingstone M, Robson P, Wallace J. 2004. Issues in dietary intake assessment of children and adolescents. Br J Nutr. 92(Suppl 2):S213–S222.

Mackenbach JD, Brage S, Forouhi NG, Griffin SJ, Wareham NJ, Monsivais P. 2015. Does the importance of dietary costs for fruit and vegetable intake vary by socioeconomic position? Br J Nutr. 114(9):1464–1470.

Magarey A, Watson J, Golley RK, Burrows T, Sutherland R, McNaughton SA, Denney-Wilson E, Campbell K, Collins C. 2011. Assessing dietary intake in children and adolescents: Considerations and recommendations for obesity research. Int J Pediatr Obes. 6(1):2–11.

Maillot M, Ferguson EL, Drewnowski A, Darmon N. 2008. Nutrient-dense food groups have high energy costs: An econometric approach to nutrient profiling. J Nutr. 138(6):1107–1113.

Monteiro CA, Moubarac J-C, Cannon G, Ng SW, Popkin B. 2013. Ultra-processed products are becoming dominant in the global food system. Obes Rev. 14 Suppl 2(Suppl 2): 21–28.

Moraeus L, Lindroos AK, Warensjö Lemming E, Mattisson I. 2020. Diet diversity score and healthy eating index in relation to diet quality and socio-demographic factors: results from a cross-sectional national dietary survey of

Swedish adolescents. Public Health Nutr. 23(10): 1754–1765.

NUBEL 2015. Extraction of the Belgian Food Composition Database and Food Composition Brand Name Database (NIMS - Nubel Information Management system). Brussels: Nubel vzw.

Ocké M, de Boer E, Van der Laan J, et al. 2012. PANCAKE – Pilot study for the Assessment of Nutrient intake and food Consumption Among Kids in Europe. Supporting Publications: EN-339 [120 pp]. Available online: www.efsa.europa.eu/publications.

Panagiotakos D. 2008. A-priori versus a-posterior methods in dietary pattern analysis: a review in nutrition epidemiology. Nutr Bull. 33(4):311–315.

Pechey R, Monsivais P. 2016. Socioeconomic inequalities in the healthiness of food choices: Exploring the contributions of food expenditures. Prev Med. 88:203–209.

Pedroni C, Castetbon K, Desbouys L, et al. 2021. The cost of diets according to nutritional quality and sociodemographic characteristics: A population-based assessment in Belgium. J Acad Nutr Diet [in Press]. S2212–2672(21): 00374–9.

Rao M, Afshin A, Singh G, Mozaffarian D. 2013. Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. BMJ Open. 3(12):e004277.

Rehm C, Monsivais P, Drewnowski A. 2011. The quality and monetary value of diets consumed by adults in the United States. Am J Clin Nutr. 94(5):1333–1339.

Rehm C, Monsivais P, Drewnowski A. 2015. Relation between diet cost and healthy eating index 2010 scores among adults in the United States 2007-2010. Prev Med. 73:70–75.

Reicks M, Randall J, Haynes B. 1994. Factors affecting consumption of fruits and vegetables by low-income families. J Am Diet Assoc. 94(11):1309–1311.

RIVM 2013. NEVO online version 2013/4.0. http://www.rivm.nl/nevo/.

Ryden P, Hagfors L. 2011. Diet cost, diet quality and socioeconomic position: how are they related and what contributes to differences in diet costs? Public Health Nutr. 14(9):1680–1692.

Schröder H, Gomez SF, Ribas-Barba L, Pérez-Rodrigo C, Bawaked RA, Fíto M, Serra-Majem L. 2016. Monetary diet cost, diet quality, and parental socioeconomic status in Spanish youth. PLoS One. 11(9):e0161422.

Schroder H, Marrugat J, Covas M. 2006. High monetary costs of dietary patterns associated with lower body mass index: a population-based study. Int J Obes. 30(10): 1574–1579.

Serra-Majem L, Ribas L, Ngo J, Ortega RM, García A, Pérez-Rodrigo C, Aranceta J. 2004. Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean diet quality index in children and adolescents. Public Health Nutr. 7(7):931–935.

Slimani N, Casagrande C, Nicolas G, Freisling H, Huybrechts I, Ocké MC, Niekerk EM, van Rossum C, Bellemans M, De Maeyer M, et al. 2011. The standardized computerized 24-h dietary recall method EPIC-Soft adapted for pan-European dietary monitoring. Eur J Clin Nutr. 65(Suppl 1):S5–S15.,

Slimani N, Fahey M, Welch AA, Wirfält E, Stripp C, Bergström E, Linseisen J, Schulze MB, Bamia C, Chloptsios Y, et al. 2002. Diversity of dietary patterns observed in the European Prospective Investigation into Cancer and Nutrition (EPIC) project. Public Health Nutr. 5(6B):1311–1328.,

StataCorp 2019a. Stata survey data reference manual - release 16. Stata Press. https://www.stata.com/manuals/svy.pdf.

StataCorp 2019b. Stata: Release 16. Statistical Software. College Station (TX): StataCorp LLC.

Štefan L, Prosoli R, Juranko D, Čule M, Milinović I, Novak D, Sporiš G. 2017. The Reliability of the Mediterranean Diet Quality Index (KIDMED) Questionnaire. Nutrients. 9(4):419.

Tong TYN, Imamura F, Monsivais P, Brage S, Griffin SJ, Wareham NJ, Forouhi NG. 2018. Dietary cost associated with adherence to the Mediterranean diet, and its variation by socio-economic factors in the UK Fenland Study. Br J Nutr. 119(6):685–694.

Willett W, Howe G, Kushi L. 1997. Adjustment for total energy intake in epidemiologic studies. Am J Clin Nutr. 65(4 Suppl):1220S–1228S.

Williams RA. 2012. Using the margins command to estimate and interpret adjusted predictions and marginal effects. The Stata Journal. 12(2):308–331.