British Journal of Nutrition (2014), **111**, 1303–1312 doi:10.1017/S0007114513003796

British Journal of Nutrition

Influence of parental socio-economic status on diet quality of European adolescents: results from the HELENA study

L. Béghin[1,2]*, L. Dauchet[3,4], Tineke De Vriendt[5,6], M. Cuenca-García[7], Y. Manios[8], E. Toti[9], M. Plada[10], K. Widhalm[11], J. Repasy[12], I. Huybrechts[5,13], M. Kersting[14], L. A. Moreno[15] and J. Dallongeville[4], on behalf of the HELENA Study Group†

[1]*CIC-PT-9301-Inserm-CH&U of Lille, CHRU de Lille, F-59037 Lille, France*
[2]*Inserm U995, IFR114/IMPRT, Université Lille Nord de France, F-59037 Lille, France*
[3]*Service d'épidémiologie régional, CHRU de Lille, F-59037 Lille, France*
[4]*Inserm, U744, Institut Pasteur de Lille, Université Lille Nord de France, Lille, France*
[5]*Department of Public Health, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium*
[6]*Research Foundation Flanders, Egmonstraat 5, Brussels, Belgium*
[7]*Department of Medical Physiology, School of Medicine, University of Granada, Granada, Spain*
[8]*University of Harakopio, Athens, Greece*
[9]*Instituto Naziolalen di Ricerca per gli Alimenti de la Nutrizione, Roma, Italy*
[10]*University of Crete School of Medicine, Heraklion, Greece*
[11]*Department of Pediatrics, Private Medical University Salzburg, Salzburg, Austria*
[12]*Department of Pediatrics, University of Pecs, Pecs, Hungary*
[13]*Dietary Exposure Assessment Group, International Agency for Research on Cancer, Lyon, France*
[14]*Forschungsinstitut für Kinderernährung, Institut an der Rheinischen Friedrich-Wilhelms-Universität Bonn, Dortmund, Germany*
[15]*GENUD (Growth, Exercise, Nutrition and Development) Research Group, Escuela Universitaria de Ciencas de la Salud, Universidad de Zaragoza, Zaragoza, Spain*

(Submitted 26 November 2012 – Final revision received 3 October 2013 – Accepted 13 October 2013 – First published online 13 December 2013)

Abstract

Diet quality is influenced by socio-economic and geographical factors. The present study sought to assess whether adolescents' diet quality is affected by their parents' socio-economic status and whether the relationship between these factors is similar in northern and southern Europe. Data collected in the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study in eight European countries were analysed. Dietary intake data were recorded via repeated 24 h recalls (using specifically developed HELENA Dietary Intake Assessment Tool software) and converted into an adolescent-specific Diet Quality Index (DQI-AM). Socio-economic status was estimated through parental educational level (Par-Educ-Lev) and parental occupation level (Par-Occ-Lev) as reported by the adolescents in a specific questionnaire. The DQI-AM data were then analysed as a function of Par-Educ-Lev and Par-Occ-Lev in northern European countries (Austria, Belgium, France, Germany and Sweden) and southern European countries (Greece, Italy and Spain). We studied a total of 1768 adolescents (age 14·7 (SD 1·3) years; percentage of girls: 52·8%; 1135 and 633 subjects from northern and southern Europe, respectively). On average, the DQI-AM score was higher in southern Europe than in northern Europe (69·1 (SD 0·1) *v.* 60·4 (SD 2·8), respectively; $P<0·001$; $\Delta = 12·6\%$). The DQI was positively correlated with both paternal and maternal Par-Educ-Lev. However, this association was more pronounced in northern Europe than in southern Europe (P interaction=0·004 for the mother and 0·06 for the father). The DQI was also positively correlated with Par-Occ-Lev (all P trends $<0·01$), but this correlation was independent of the geographical area (P interaction=0·51 for the mother and 0·50 for the father). In conclusion, Par-Educ-Lev and Par-Occ-Lev are associated with diet quality in adolescents in Europe. However, this association differs between northern Europe and southern Europe.

Key words: Diet Quality Index: Adolescence: Educational level

---

Abbreviations: DQI, Diet Quality Index; DQI-AM, Diet Quality Index for Adolescents with a specific Meal index; FBDG, food-based dietary guidelines; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; HELENA-DIAT, Healthy Lifestyle in Europe by Nutrition in Adolescence Dietary Intake Assessment Tool; ISCED, International Standard Classification of Education; Par-Educ-Lev, parental educational level; Par-Occ-Lev, parental occupation level.

* **Corresponding author:** Dr L. Béghin, fax +33 3 20 44 66 87, email laurent.beghin@chru-lille.fr

† See the Appendix for a full list of the HELENA study group members.

A well-balanced diet has an important role in the maintenance of good health during different periods of life[1]. During childhood and adolescence, in particular, the diet should meet specific needs, such as provision of an adequate energy and nutrient supply for optimal development and growth and high levels of physical activity[2]. Adolescence is also a period when individuals have increasing control over their food choices[3] and develop dietary habits that continue into adulthood[4–6]. Dietary habits are habitual decisions that a person makes when choosing what foods to eat. Dietary habits could be assessed using a large variety of methodologies such as FFQ, food choice questionnaires, and quantitative and qualitative dietary records. Data obtained using the last methodology (i.e. dietary records) could be computed/translated into a predefined diet quality score[7], such as the Diet Quality Index (DQI) used in the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study[8].

Dietary habits are influenced by personal factors (individual food choice decision, food choice motivations, religious adherence, craving, etc.) and social/environmental context[9]. It has been clearly established that dietary habits are strongly influenced by socio-economic status[10–13]. Several studies have particularly focused on certain foods and nutrients such as fruit and vegetables, fibre and SFA[14–18]. Dietary habits are also influenced by cultural traditions, which differ from one country (or indeed region) to another[19]. Although contemporary lifestyles tend to dissipate traditional habits, there are still major differences in dietary habits between European countries[19,20].

Previous studies have shown that diet quality in adulthood is differentially influenced by both socio-economic[21] and geographical factors; for example, Roos *et al.*[22] have demonstrated clear disparities in fruit and vegetable consumption between northern Europe and southern Europe. When studying the combined influence of socio-economic and geographical factors, Wyndels *et al.*[23] found that socio-economic factors influenced diet quality in adulthood in France and that this influence varied from one region to another. An adolescent's dietary habits and diet quality are strongly influenced by his/her parents' behaviours[24] and socio-economic status. In contrast, little is known about the relationships between parents' socio-economic status and their adolescent child's dietary habits in different geographical areas. The aim of the present study was to assess the influence of parental socio-economic factors on adolescents' diet quality and whether the relationship between these factors differed between northern Europe and southern Europe.

Subjects and methods

Sample

Data analysed in the present study were collected as part of the HELENA study, which was carried out between 2006 and 2007 in a number of cities in northern Europe (Vienna in Austria, Ghent in Belgium, Lille in France, Dortmund in Germany and Stockholm in Sweden) and southern Europe (Athens in Greece, Roma in Italy and Zaragoza in Spain (Fig. 1)), as described previously[25]. Briefly, the HELENA study was designed to obtain reliable, comparable data on dietary habits, dietary patterns, body composition and physical activity levels and fitness of European adolescents aged 12·5–17·5 years. Details of the sampling procedures, field team preparation, pilot study and data reliability are reported elsewhere[26]. The study was carried out in accordance with the (1) ethical guidelines of the Declaration of Helsinki, (2) good clinical practice and (3) the legislation concerning clinical research in each of the participating countries. The protocol was approved by the appropriate independent ethics committee for each study centre, and written informed consent was obtained from both parents and adolescents[27]. In total, 3865 adolescents were enrolled through their schools, which were randomly selected according to a proportional cluster sampling methodology that took age and socio-economic status into account[28]. Fig. 1 shows the distribution of study population among the countries assessed in the HELENA study, with 1135 and 633 participants from northern and southern Europe, respectively. Table 1 summarises the mean age and mean BMI of the participants and the distribution of educational and occupation levels of the study population. The study population consisted of 1768 participants (proportion of females: 52·8 %); the mean age of the study population was 14·7 (SD 1·3) years (separately for the boys and girls). The mean BMI of the participants from southern Europe was slightly but significantly higher than that of the participants from northern Europe ($P<0·0001$). A high educational and occupational level was more frequent in mothers and fathers from northern countries than in those from southern countries (all $P<0·0001$).

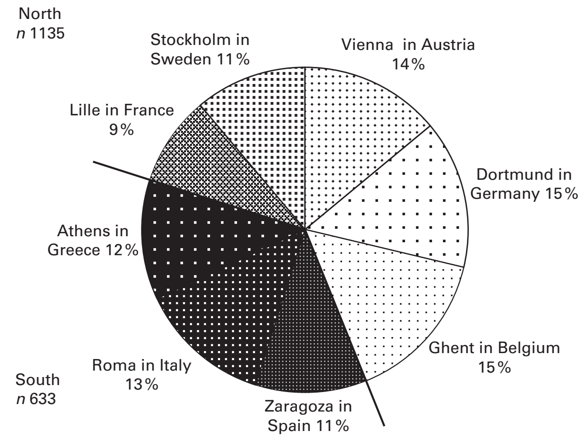

Fig. 1. Repartition of adolescents from European countries analysed in the present study between North and South regions.

Assessment of diet quality

Dietary intake was assessed by two non-consecutive 24 h recalls[29] carried out during any two convenient days in the week. As 24 h recalls could not be carried out at schools on Saturdays and Sundays, dietary intake data were not collected on Fridays and Saturdays. The 24 h recalls were recorded using a self-administered, computer-based HELENA Dietary

Table 1. Comparison of the clinical and socio-economic characteristics of the study population in the North and South regions

(Mean values and standard deviations; number of subjects and percentages)

	North		South		
	Mean	SD	Mean	SD	*P*
n	1135		633		
Female (%)	52·7		52·9		0·92
Age (years)	14·8	1·3	14·6	1·4	< 0·0001
BMI (kg/m^2)	20·2	3·0	21·3	3·6	< 0·0001
	Mother	Father	Mother	Father	
Educational level (%)					
Low	34	36	26	31	
Medium	26	23	41	36	< 0·0001
High	40	40	33	33	
Occupation level (%)					
Low	9	20	22	28	
Medium	43	26	35	37	< 0·0001
High	20	36	13	18	
Undefined/missing	28	17	30	18	

Intake Assessment Tool (HELENA-DIAT) that has been validated in European adolescents[30]. The HELENA-DIAT is based on the assessment of dietary intakes during six meal occasions (breakfast, morning snacks, lunch, afternoon snacks, evening meal and evening snacks) on the previous day. Trained dietitians assisted the adolescents to complete the 24 h recalls when needed. The adolescents selected all the foods and beverages consumed at each meal occasion from a standardised food list. Items not present in the initial list could be added by the participants any time. To calculate energy and nutrient intakes, data from the HELENA-DIAT were linked to the German Food Code and Nutrient Database (Bundeslebensmittelschlüssel, version II.3.1)[31]. Given that nutrient contents in different national or regional food composition tables are determined using different laboratory techniques, intakes of only a few nutrient classes could be calculated on the basis of the local food composition tables. Therefore, we decided to include the German food composition table (which included a large number of nutrients and food items) for further nutrient intake assessments. The Multiple Source Method was used to estimate the usual energy, nutrient and food intakes. This statistical modelling technique takes into account the within-person and between-person variability and calculates usual intakes corrected for age, sex and study centre[32].

To assess adolescents' diet quality, data from the HELENA-DIAT were converted into the Diet Quality Index for Adolescents, including a specific Meal index (DQI-AM). A previously validated DQI (originally developed for preschool children)[33] was adapted for use in adolescents and measurement of their compliance with the Flemish food-based dietary guidelines (FBDG)[34]. The latter are based on three basic principles for a healthy diet: quality; diversity; balance. Furthermore, the daily diet was divided into nine recommended food groups, namely (1) water, (2) bread and cereals, (3) grains and potatoes, (4) vegetables, (5) fruit, (6) milk products (7), cheese, (8) meat, fish, eggs and substitutes, and (9) fats and oils. Milk products and cheese were allocated to different food groups because of the large range of fat contents. Despite differences in nutrient content, meat and fish were placed in the same food group, because the FBDG recommend an intake of 75–100 g of meat, fish, poultry or meat replacement products per d. The FBDG also recommend eating fish twice a week; however, with only two 24 h recall registrations, this frequency was difficult to assess and therefore was not taken into account in the DQI-AM calculation. For each of the food groups, a range of recommended daily intake levels, specifically for adolescents, were determined using the Belgian food-based dietary guidelines (based on the nutrient recommendations of the Belgian Health Council[35] and the WHO and data on typical dietary intake levels in the Belgian population). These recommendations were very similar to (1) the FBDG in other countries and (2) the Countrywide Integrated Non-communicable Disease Intervention Program pyramid developed by the WHO[36]. Therefore, we considered the index to be applicable to populations across Europe. Given that consuming at least three main meals per d (breakfast, lunch and dinner) is also recommended, we also included a 'meal component' item in our DQI-AM to evaluate the frequency of consumption of these meals on a weekly basis.

The technical aspects of the calculation of the DQI-AM have been described by Vyncke *et al.*[37]. In summary, the DQI-AM consisted of the arithmetic mean of four components, also included in the FBDG: diet quality; dietary diversity; dietary balance; meal frequency. Diet quality corresponds to whether adolescents made the optimal food choices within a food group with respect to quality and whether the food chosen was represented by a 'preference group' (e.g. fish, fresh fruit, cereal/brown bread), a 'moderation group' (e.g. white bread, minced meat) or a 'low-nutrient, energy-dense group' (e.g. chicken nuggets, soft drinks, sweet snacks). Dietary diversity corresponds to the degree of variation in the diet. This component was determined by awarding points (ranging from 0 to 9) when at least one serving of food from a recommended food group was consumed. Dietary

https://doi.org/10.1017/S0007114513003796 Published online by Cambridge University Press https://doi.org/10.1017/S0007114513003796 Published online by Cambridge University Press

British Journal of Nutrition

balance was calculated as the difference between the adequacy component (the percentage of the minimum recommended intake for each of the main food groups) and the excess component (the percentage of intake exceeding the recommendation's upper level). A meal occasion was scored 0 when no food was consumed and 1 when some food was consumed. The scores for the three occasions were summed and are expressed as a percentage; the possible scores were thus 0 % (no consumption during any of the main meal occasions), 33 % (consumption during only one main meal occasion), 66 % (consumption during two main meal occasions) and 100 % (consumption during all the three main meal occasions).

The four DQI-AM components are presented below as percentages. The quality component ranged from −100 to 100 %, whereas the diversity, balance and meal components ranged from 0 to 100 %. The DQI-AM was computed as the mean of these four components; hence, the DQI-AM ranged from −25 to 100 %, with higher scores reflecting a higher-quality diet. The score was calculated for each day, and the mean daily score was taken as the individual's overall index.

Assessment of parental educational level

Parental educational level (Par-Educ-Lev) data were collected using a specific questionnaire already described by Iliescu *et al.*[26]. In each country, Par-Educ-Lev were adapted from the International Standard Classification of Education (ISCED) (http://www.uis.unesco.org/Library/Documents/isced97-en.pdf, viewed on 27th August 2012). Par-Educ-lev as reported by the adolescents was categorised into four groups: primary education (ISCED level 0 or 1; score = 1); lower secondary education (ISCED level 2; score = 2); higher secondary education (ISCED level 3 or 4; score = 3); tertiary education (ISCED level 5 or 6; score = 4). For the purposes of the present study, we merged the two lower levels into one group (i.e. 'primary education and lower secondary education') and obtained three groups: low; medium; high ('low' was the lowest parental occupation level (Par-Occ-Lev) and 'high' was the highest Par-Occ-Lev). The original coding was retained when calculating the *P* trend values.

Assessment of parental occupation level

Par-Occ-Lev data were collected as a surrogate marker of socio-economic status via completion of a specific questionnaire[26]. Par-Occ-Lev data were collected according to the International Standard Classification of Occupation (http://unstats.un.org/unsd/class/family/family2.asp?Cl = 224, viewed on 27th August 2012). The categories were scored from 1 (the highest level) to 9 (the lowest level). For the purposes of the present study, we merged the two highest levels (score 1 or 2); the medium levels (scores 3 to 5) and the lowest levels (scores 6 to 9) and obtained three groups: high; medium; low (where 'low' was the lowest Par-Occ-Lev and 'high' was the highest Par-Occ-Lev). The original coding was retained when calculating the *P* trend values.

Statistical analysis

Descriptive characteristics are presented as mean values and standard deviations for continuous variables and as percentage for categorical variables. Statistical analysis was carried out using the SAS software (version 9.1, SAS Institute, Inc.). Pearson's χ^2 tests and *t* tests were used to test between-sex differences for categorical and continuous variables, respectively.

North–south trends were calculated to estimate the statistical significance of putative associations between Par-Occ-Lev and Par-Educ-Lev, on the one hand, and those between the DQI-AM and its components, on the other hand. We calculated *P* interaction between Par-Occ-Lev or Par-Educ-Lev and region (north–south) to determine whether the associations were significantly stronger in one of the regions.

Linear, multilevel mixed models (the MIXED procedure in SAS) were used to account for multistratum sampling. The dependent variable (outcome) included in the MIXED model was the DQI-AM or its components. The independent variables were maternal or paternal Par-Occ-Lev or Par-Educ-Lev, region (north, south) and the interaction between the two variables. Centre, school and class were included as random-effect variables. *P* trend and *P* interaction were calculated using Par-Occ-Lev and Par-Educ-Lev as continuous variables (from 1 to 4 for Par-Occ-Lev and from 1 to 3 for Par-Educ-Lev).

Results

In Table 2, the dietary intakes of adolescents in northern and southern Europe are compared. The mean intakes of fruit and vegetable juice, starch roots, potatoes, bread and rolls, cereals, butter and animal fat, and yogurt were higher in northern

Table 2. Comparison of the food intake characteristics of the study population in the North and South regions

(Mean values and standard deviations)

	North		South		
	Mean	SD	Mean	SD	*P*
Food intake (g/d)					
Water	649	17	914	22	<0·0001
Bread and cereals	157	3	121	4	<0·0001
Grains and potatoes	75	3	49	3	<0·0001
Vegetables	87	3	121	5	<0·0001
Fruit	144	4	128	6	<0·04
Milk products	301	10	251	8	<0·0001
Cheese	30	1	37	2	<0·002
Meat, fish, eggs and substitutes	171	4	237	7	<0·0001
Fats and oils	18	1	22	1	<0·005
DQI and related scores					
DQI-AM	60·4	13·6	69·6	10·2	<0·0001
DQI diversity	77·6	12·4	82·9	11·1	<0·0001
DQI quality	32·7	36·6	59·3	24·1	<0·0001
DQI equilibrium	39·8	10·6	44·2	9·7	<0·0001
DQI meal	94·0	11·6	94·4	11·0	0·42

DQI, Diet Quality Index; DQI-AM, Diet Quality Index for Adolescents with a specific Meal index.

Europe than in southern Europe, whereas those of fruit and vegetables, pulses, meat, eggs, milk and buttermilk, and fish were higher in southern Europe than in northern Europe (all $P<0.05$). The mean overall DQI-AM score and the scores of all its components were higher in southern Europe than in northern Europe ($P<0.001$), with the exception of that of the DQI meal component (Table 2).

The mean DQI-AM scores by Par-Educ-Lev and Par-Occ-Lev groups are shown for each region in Fig. 2. In a model adjusted for sex, age and energy intake, the interaction between region and maternal educational level was statistically significant ($P<0.004$). The average DQI-AM score was higher in southern Europe than in northern Europe (60·4 (SD 2·8) *v.* 69·1 (SD 0·1), respectively; $P<0.001$; $\Delta = 12.6\%$) and was associated with maternal educational level (P trend <0.001) in northern Europe but not in southern Europe (P trend$=0.1$). Similarly, the interaction between region and paternal educational level was borderline significant ($P<0.06$). In a similar model adjusted for sex, age and energy intake, the interactions between region and maternal and paternal occupation levels were not statistically significant ($P=0.50$). Both maternal and paternal Par-Occ-Lev were associated with the DQI-AM in southern and northern Europe.

The relationships between DQI scores and Par-Educ-Lev or Par-Occ-Lev in northern and southern Europe are summarised in Table 3. Par-Educ-Lev was more strongly correlated with all the DQI-AM components (namely diversity, quality, balance and meal index) in northern Europe than in southern Europe (all the interactions with maternal educational level were significant, except for the meal component). The increase in the DQI component *Z*-score for an increment of one category in maternal educational level ranged from 0·10 to 0·21 in northern Europe and from 0·02 to 0·06 in southern Europe. All but one of the P trends (paternal educational level/meal component) were significant in northern Europe, whereas only the association with dietary balance achieved significance in southern Europe. Graphical representations of each of the DQI-AM components and their interactions with maternal and paternal Par-Educ-Lev or Par-Occ-Lev are shown by region in Supplementary Figs. 1 and 2 (available online).

Discussion

Diet quality is strongly influenced by socio-economic factors; however, little is known about the relationship between them in adolescence[38–40]. The aim of the present study was to assess the influence of parental socio-economic status on adolescents' diet quality and establish whether the relationship between these factors differs between northern Europe and southern Europe.

The results of the HELENA study indicate that the relationship between adolescents' diet quality (as assessed by the DQI-AM) and Par-Educ-Lev differs between northern and southern regions, namely the quality of adolescents' diet was positively correlated with Par-Educ-Lev in northern Europe but not in southern Europe. This suggests that cultural and geographical factors (which affect diet quality) could attenuate the relationship between Par-Educ-Lev and adolescents' diet quality – in countries where the diet is generally healthy (such as in southern Europe). In contrast, Par-Occ-Lev (which is related to family's wealth) was found to be positively associated with adolescents' diet quality in both northern and southern Europe, suggesting that parents' economic constraints may have an impact on adolescents' diet quality independently of the geographical area.

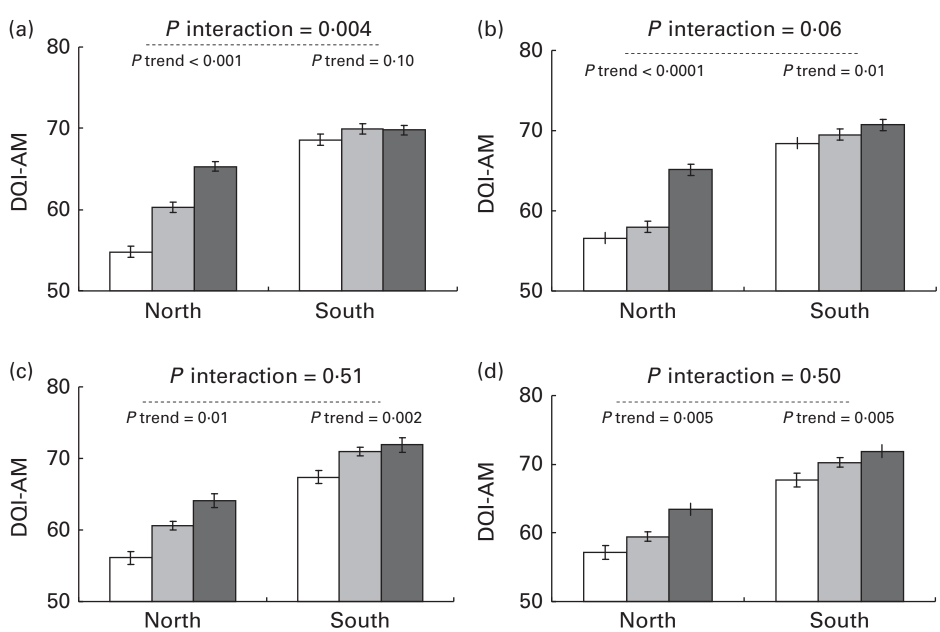

Fig. 2. Mean scores of the Diet Quality Index for Adolescents with a specific Meal index (DQI-AM) by region according to parents' educational level ((a) mother, (b) father) and parents' occupation level ((c) mother, (d) father). □, Low; ▒, medium; ■, high.

Table 3. Relationship between the Diet Quality Index (DQI) scores and parental educational or occupation levels in the North and South regions
(β-Coefficients with their standard errors)

	Mother							Father						
	North			South				North			South			
	β*	SEM	*P* trend	β*	SEM	*P* trend	*P* interaction	β*	SEM	*P*	β*	SEM	*P*	*P* interaction
Educational level														
DQI-AM	0·21	0·03	0·0001	0·06	0·04	0·10	0·004	0·18	0·03	< 0·0001	0·09	0·04	0·01	0·06
DQI diversity	0·16	0·03	< 0·0001	0·05	0·04	0·19	0·04	0·15	0·03	< 0·0001	0·06	0·04	0·10	0·11
DQI quality	0·16	0·03	< 0·0001	0·03	0·04	0·42	0·01	0·16	0·03	< 0·0001	0·05	0·04	0·12	0·03
DQI equilibrium	0·21	0·03	< 0·0001	0·09	0·04	0·040	0·02	0·18	0·03	< 0·0001	0·09	0·04	0·01	0·12
DQI meal	0·10	0·03	< 0·004	0·02	0·04	0·52	0·19	0·05	0·03	< 0·14	0·06	0·04	0·10	0·73
Occupation level														
DQI-AM	0·14	0·05	0·01	0·19	0·05	0·002	0·51	0·11	0·04	0·005	0·14	0·05	0·005	0·50
DQI diversity	0·10	0·05	0·06	0·20	0·06	0·002	0·23	0·10	0·04	0·1	0·09	0·06	0·11	0·88
DQI quality	0·11	0·05	0·02	0·14	0·05	0·02	0·74	0·07	0·04	0·05	0·13	0·05	0·01	0·34
DQI equilibrium	0·14	0·05	0·01	0·19	0·06	0·002	0·53	0·13	0·04	0·001	0·13	0·06	0·02	0·96
DQI meal	0·09	0·05	0·12	0·06	0·06	0·4	0·73	0·08	0·04	0·06	0·05	0·06	0·38	0·73

DQI-AM, Diet Quality Index for Adolescents with a specific Meal index.
* Parameter estimate from the stepwise multilevel linear regression coefficient.

The positive correlation between Par-Educ-Lev and the DQI-AM score observed in northern Europe could be related to the fact that well-educated people (1) make more reasoned healthy food choices for their adolescent children because they better understand nutritional messages[41], (2) adopt healthy dietary habits more easily and more quickly than less-educated people[21,22,42–44], (3) have better nutritional knowledge, which may be translated into healthier food choices/messages for the entire family (including adolescents)[45–47], and (4) live in a healthy environment providing more opportunities for better-quality foodstuff purchase and consumption than neighbourhood low-cost supermarkets used by less-educated people[48]. In southern Europe (in the Mediterranean), the more favourable nutritional environment tends to homogenise adolescents' dietary habits in a favourable manner and thus attenuates the influence of Par-Educ-Lev on diet quality[49,50].

In contrast, the association between Par-Occ-Lev (a proxy of family's wealth) and adolescents' diet quality did not depend on the geographical area – suggesting that financial constraints are an important determinant of food choice, independently of cultural factors[51]. This is supported by the observation that food cost represents a barrier to the adoption of dietary advice by low-income people all over the world[21,52]. In multivariate models that included both Par-Educ-Lev and Par-Occ-Lev[53], the latter indicators were still independently associated with diet quality; this suggests that the contribution of Par-Educ-Lev to diet quality is independent of Par-Occ-Lev (and vice versa).

In the present study, diet quality was assessed by the DQI-AM[8], which is a composite of diversity, quality, balance and meal index subscores. Consistent associations of similar strength were observed between Par-Educ-Lev and the scores of all the DQI-AM components in northern Europe, and no or weak association was observed in southern Europe. This suggests that cultural and geographical factors have a broad impact on the components of diet quality related to Par-Educ-Lev.

In northern Europe, adolescents' diet quality was significantly better when maternal educational level was high. A similar (but less pronounced) association was observed for paternal educational level. This finding suggests that maternal educational level is a strong determinant of diet quality. In agreement with this hypothesis, communication between parents and their adolescent children is an important issue in children's nutritional behaviour[47]. It is known that within a family, mother–child communication is more effective than father–child communication[54]. In the HELENA study, this conclusion is supported by results from the Healthy Eating Questionnaire showing that mother is the family member most likely to promote healthy dietary habits[26]. In contrast, the relationships between parental socio-economic status and adolescents' diet quality were similar for boys and girls (Table S2, available online). Other determinants related to diet and environment could explain the difference observed between northern Europe and southern Europe, such as school rhythms between the two regions. During school period, the majority of adolescents from southern Europe have no lessons in the afternoon (data not published) and may probably go to their homes for lunch (60·0 *v.* 49·6 % of the adolescents lunch at home in southern *v.* northern Europe; *P*< 0·0001; Table S3, available online). In contrast, adolescents from northern Europe preferably lunch at school restaurant/canteen compared with southern adolescents (27·6 *v.* 6·4 %, respectively; *P*< 0·0001; Table S4, available online). It is well recognised that school meals promote healthy dietary habits[55–57]; however, this may not be sufficient to counteract the relationship with parents' educational level. Furthermore, although adolescents from northern Europe declared more often to have access to healthy food at school compared with adolescents from southern Europe (57·8 *v.* 28·2 %, respectively; *P*< 0·0001; Table S3, available online), the same trend was observed for non-healthy food (biscuits, chips or sugar beverages). Adolescents from northern Europe declared to have less access to non-healthy food compared with adolescents from southern Europe (67·0 *v.* 78·1 %, respectively; *P*< 0·0001; Table S3, available online). These observations suggest that other determinants, especially school environment or dietary habits of adolescents, may affect the relationship between Par-Educ-Lev and adolescents' diet quality.

The present study has a number of strengths, including the large sample size and the use of a common methodology and standardised procedures across all the study centres. The tools used to collect data on diet quality, Par-Educ-Lev and Par-Occ-Lev have been tested and validated in European populations[26,30]. In contrast, the locations of the study centres (i.e. large cities) are not ideal representatives of north *v.* south lifestyle differences and thus the present results will have to be confirmed in different datasets. Furthermore, public health programmes and government initiatives aiming at promoting healthy dietary habits (Table S1, available online) are essentially focused at the country level. Therefore, it is difficult to take into account these issues in our analyses. Lastly, the cross-sectional design of the HELENA study prevents inferring causal relationships.

In conclusion, we found that Par-Educ-Lev had an impact on the diet quality of European adolescents. However, the relationship between these factors differed when comparing northern Europe with southern Europe. This finding has implications for educational and public health policies. The presence of education-related differences suggests that there is a need for appropriate, locally delivered nutritional education programmes[54], whereas welfare policies could be applied across the country as a whole[41]. Furthermore, programmes for adolescents should be adapted as a function of Par-Educ-Lev and adolescents' geographical location[58]. Further research should assess the impact of public health programmes and state initiatives promoting healthy dietary habits in adolescents and in other populations.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S0007114513003796

Acknowledgements

The authors thank Muriel Beuvry and Anne Gautreau (CIC-9301-CH&U-Inserm de Lille, France) for help in typing the manuscript.

The HELENA Study was carried out with the financial support of the European Community Sixth RTD Framework Programme (Contract FOOD-CT-20056007034). The present study was also supported by grants from the Spanish Ministry of Science and Innovation (AP 2008-03806). The content of this article reflects only the authors' views and the European Community is not liable for any use that may be made of the information contained herein. The European Community had no role in the design and analysis of the study or in the writing of this article.

The authors' contributions are as follows: L. A. M. coordinated the HELENA project at the international level; L. A. M., Y. M., M. K., K. W. and J. D. were involved in the design of the HELENA project and locally coordinated the HELENA project; L. B., T. D. V., M. C.-G., E. T. and M. P. organised the fieldwork and collected the data locally; I. H. was responsible for the database management and T. D. V. was responsible for DQI computations; L. B. was responsible for regulatory issues; L. D. carried out the statistical analysis; L. B. and L. D. drafted the article. All authors read and approved the final manuscript.

None of the authors has any conflicts of interest to declare.

References

1. Potter JD (1997) *Food, Nutrition and the Prevention of Cancer: A Global Perspective*. World Cancer Research Fund and American Institute for Cancer Research. http://eprints.ucl.ac.uk/4841/1/4841.pdf
2. Fraser GE & Shavlik DJ (2001) Ten years of life: is it a matter of choice? *Arch Intern Med* **161**, 1645–1652.
3. Videon TM & Manning CK (2003) Influences on adolescent eating patterns: the importance of family meals. *J Adolesc Health* **32**, 365–373.
4. Birch LL (1998) Psychological influences on the childhood diet. *J Nutr* **128**, 407S–410S.
5. Lien N, Jacobs DR Jr & Klepp KI (2002) Exploring predictors of eating behaviour among adolescents by gender and socio-economic status. *Public Health Nutr* **5**, 671–681.
6. Scaglioni S, Salvioni M & Galimberti C (2008) Influence of parental attitudes in the development of children eating behaviour. *Br J Nutr* **99**, Suppl. 1, S22–S25.
7. Waijers PM, Feskens EJ & Ocke MC (2007) A critical review of predefined diet quality scores. *Br J Nutr* **97**, 219–231.
8. Vyncke K, Cruz FE, Fajo-Pascual M, *et al.* (2013) Validation of the Diet Quality Index for Adolescents by comparison with biomarkers, nutrient and food intakes: the HELENA study. *Br J Nutr* **109**, 2067–2078.
9. Furst T, Connors M, Bisogni CA, *et al.* (1996) Food choice: a conceptual model of the process. *Appetite* **26**, 247–265.
10. Johansson L, Thelle DS, Solvoll K, *et al.* (1999) Healthy dietary habits in relation to social determinants and lifestyle factors. *Br J Nutr* **81**, 211–220.
11. Kant AK & Graubard BI (2007) Secular trends in the association of socio-economic position with self-reported dietary attributes and biomarkers in the US population: National Health and Nutrition Examination Survey (NHANES)

1971–1975 to NHANES 1999–2002. *Public Health Nutr* **10**, 158–167.
12. Hulshof KF, Brussaard JH, Kruizinga AG, *et al.* (2003) Socio-economic status, dietary intake and 10 y trends: the Dutch National Food Consumption Survey. *Eur J Clin Nutr* **57**, 128–137.
13. Lallukka T, Laaksonen M, Rahkonen O, *et al.* (2007) Multiple socio-economic circumstances and healthy food habits. *Eur J Clin Nutr* **61**, 701–710.
14. Irala-Estevez JD, Groth M, Johansson L, *et al.* (2000) A systematic review of socio-economic differences in food habits in Europe: consumption of fruit and vegetables. *Eur J Clin Nutr* **54**, 706–714.
15. Vereecken CA, Inchley J, Subramanian SV, *et al.* (2005) The relative influence of individual and contextual socio-economic status on consumption of fruit and soft drinks among adolescents in Europe. *Eur J Public Health* **15**, 224–232.
16. Estaquio C, Castetbon K, Kesse-Guyot E, *et al.* (2008) The French National Nutrition and Health Program score is associated with nutritional status and risk of major chronic diseases. *J Nutr* **138**, 946–953.
17. Estaquio C, Druesne-Pecollo N, Latino-Martel P, *et al.* (2008) Socioeconomic differences in fruit and vegetable consumption among middle-aged French adults: adherence to the 5 A Day recommendation. *J Am Diet Assoc* **108**, 2021–2030.
18. Hart A Jr, Tinker L, Bowen DJ, *et al.* (2006) Correlates of fat intake behaviors in participants in the eating for a healthy life study. *J Am Diet Assoc* **106**, 1605–1613.
19. Trichopoulou A (2007) Traditional food: a science and society. *Trends Food Sci Technol* **18**, 420–427.
20. Slimani N, Fahey M, Welch AA, *et al.* (2002) Diversity of dietary patterns observed in the European Prospective Investigation into Cancer and Nutrition (EPIC) project. *Public Health Nutr* **5**, 1311–1328.
21. Darmon N & Drewnowski A (2008) Does social class predict diet quality? *Am J Clin Nutr* **87**, 1107–1117.
22. Roos G, Johansson L, Kasmel A, *et al.* (2001) Disparities in vegetable and fruit consumption: European cases from the north to the south. *Public Health Nutr* **4**, 35–43.
23. Wyndels K, Dallongeville J, Simon C, *et al.* (2011) Regional factors interact with educational and income tax levels to influence food intake in France. *Eur J Clin Nutr* **65**, 1067–1075.
24. Deshmukh-Taskar P, Nicklas TA, Yang SJ, *et al.* (2007) Does food group consumption vary by differences in socioeconomic, demographic, and lifestyle factors in young adults? The Bogalusa Heart Study. *J Am Diet Assoc* **107**, 223–234.
25. Moreno LA, De HS, Gonzalez-Gross M, *et al.* (2008) Design and implementation of the Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study. *Int J Obes (Lond)* **32**, Suppl. 5, S4–S11.
26. Iliescu C, Beghin L, Maes L, *et al.* (2008) Socioeconomic questionnaire and clinical assessment in the HELENA Cross-Sectional Study: methodology. *Int J Obes (Lond)* **32**, Suppl. 5, S19–S25.
27. Beghin L, Castera M, Manios Y, *et al.* (2008) Quality assurance of ethical issues and regulatory aspects relating to good clinical practices in the HELENA Cross-Sectional Study. *Int J Obes (Lond)* **32**, Suppl. 5, S12–S18.
28. Beghin L, Huybrechts I, Vicente-Rodriguez G, *et al.* (2012) Main characteristics and participation rate of European adolescents included in the HELENA study. *Arch Public Health* **70**, 14.
29. Biro G, Hulshof KF, Ovesen L, *et al.* (2002) Selection of methodology to assess food intake. *Eur J Clin Nutr* **56**, Suppl. 2, S25–S32.
30. Vereecken CA, Covents M, Sichert-Hellert W, *et al.* (2008) Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe. *Int J Obes (Lond)* **32**, Suppl. 5, S26–S34.
31. Dehne LI, Klemm C, Henseler G, *et al.* (1999) The German Food Code and Nutrient Data Base (BLS II.2). *Eur J Epidemiol* **15**, 355–359.
32. Haubrock J, Hartigg U & Souverein O (2010) An improved statistical tool for estimating usual intake distributions: The Multiple Source Method (MSM). *Arch Public Health* **68**, 14–15.
33. Huybrechts I, Vereecken C, De Bacquer D, *et al.* (2010) Reproducibility and validity of a diet quality index for children assessed using a FFQ. *Br J Nutr* **104**, 135–144.
34. VIG (2012) *De actieve voedingsdriehoek: een praktische voedings – en beweeggids (*The Active Food Pyramid: A Practical Guide to Dies and Physical Activity*)*. Brussels: Vlaams Instituut voor Gezondheidspromotie (VIG).
35. Belgian Health Council (2012) *Voedingsaanbevelingen voor België: Herziene versie (*Dietary Guidelines for Belgium: Revised Version*)*. Brussels: Belgian Health Council (2009).
36. EUFIC (2011) The European Food Information Council. http://www.eufic.org/article/en/page/RARCHIVE/expid/food-based-dietary-guidelines-in-europe/ (accessed September 2011).
37. Vyncke K, Cruz-Fernandez E, Fajo-Pascual M, *et al.* (2013) Validation of the Diet Quality Index for adolescents by comparison with biomarkers, nutrient and food intakes: the HELENA study. *Br J Nutr* **109**, 2067–2078.
38. Neumark-Sztainer D, Wall M, Perry C, *et al.* (2003) Correlates of fruit and vegetable intake among adolescents. Findings from Project EAT. *Prev Med* **37**, 198–208.
39. De Bourdeaudhuij I & Van Oost P (2000) Personal and family determinants of dietary behaviour in adolescents and their parents. *Psycol Health* **15**, 751–770.
40. Kremers SP, Brug J, de Vries H, *et al.* (2003) Parenting style and adolescent fruit consumption. *Appetite* **41**, 43–50.
41. Turrell G, Hewitt B, Patterson C, *et al.* (2003) Measuring socio-economic position in dietary research: is choice of socio-economic indicator important? *Public Health Nutr* **6**, 191–200.
42. Drewnowski A & Darmon N (2005) Food choices and diet costs: an economic analysis. *J Nutr* **135**, 900–904.
43. Prattala RS, Groth MV, Oltersdorf US, *et al.* (2003) Use of butter and cheese in 10 European countries: a case of contrasting educational differences. *Eur J Public Health* **13**, 124–132.
44. Roos E, Talala K, Laaksonen M, *et al.* (2008) Trends of socioeconomic differences in daily vegetable consumption, 1979–2002. *Eur J Clin Nutr* **62**, 823–833.
45. Dallongeville J, Marecaux N, Cottel D, *et al.* (2001) Association between nutrition knowledge and nutritional intake in middle-aged men from Northern France. *Public Health Nutr* **4**, 27–33.
46. Hendrie GA, Coveney J & Cox D (2008) Exploring nutrition knowledge and the demographic variation in knowledge levels in an Australian community sample. *Public Health Nutr* **11**, 1365–1371.
47. Sichert-Hellert W, Beghin L, De Henauw S, *et al.* (2011) Nutritional knowledge in European adolescents: results from the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) study. *Public Health Nutr* **14**, 2083–2091.
48. Jetter KM & Cassady DL (2006) The availability and cost of healthier food alternatives. *Am J Prev Med* **30**, 38–44.
49. Keys A, Menotti A, Karvonen MJ, *et al.* (1986) The diet and 15-year death rate in the seven countries study. *Am J Epidemiol* **124**, 903–915.

50. Trichopoulou A & Lagiou P (1997) Healthy traditional Mediterranean diet: an expression of culture, history, and lifestyle. *Nutr Rev* **55**, 383–389.
51. Turrell G & Kavanagh AM (2006) Socio-economic pathways to diet: modelling the association between socio-economic position and food purchasing behaviour. *Public Health Nutr* **9**, 375–383.
52. Drewnowski A & Specter SE (2004) Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr* **79**, 6–16.
53. Braveman PA, Cubbin C, Egerter S, *et al.* (2005) Socioeconomic status in health research: one size does not fit all. *JAMA* **294**, 2879–2888.
54. Kim C, Hanjoon L & Marc A (2009) Adolescents' perceptions of family communication patterns and some aspects of their consumer socialization. *Psychol Market* **26**, 888–907.
55. Raulio S, Roos E & Prattala R (2010) School and workplace meals promote healthy food habits. *Public Health Nutr* **13**, 987–992.
56. Dubuisson C, Lioret S, Dufour A, *et al.* (2012) Associations between usual school lunch attendance and eating habits and sedentary behaviour in French children and adolescents. *Eur J Clin Nutr* **66**, 1335–1341.
57. Lopez-Frias M, Nestares T, Ianez I, *et al.* (2005) Nutrient intake adequacy in schoolchildren from a Mediterranean area (southern Spain). Influence of the use of the school canteen. *Int J Vitam Nutr Res* **75**, 312–319.
58. Coleman KJ, Shordon M, Caparosa SL, *et al.* (2012) The healthy options for nutrition environments in schools (Healthy ONES) group randomized trial: using implementation models to change nutrition policy and environments in low income schools. *Int J Behav Nutr Phys Act* **9**, 80.

Appendix: HELENA Study Group

Coordinator: Luis A. Moreno

Core Group members: Luis A. Moreno, Frédéric Gottrand, Stefaan De Henauw, Marcela González-Gross, Chantal Gilbert

Steering Committee: Anthony Kafatos (President), Luis A. Moreno, Christian Libersa, Stefaan De Henauw, Jackie Sánchez, Fréderic Gottrand, Mathilde Kersting, Michael Sjöstrom, Dénes Molnár, Marcela González-Gross, Jean Dallongeville, Chantal Gilbert, Gunnar Hall, Lea Maes, Luca Scalfi

Project Manager: Pilar Meléndez

Universidad de Zaragoza (Spain)

Luis A. Moreno, Jesús Fleta, José A. Casajús, Gerardo Rodríguez, Concepción Tomás, María I. Mesana, Germán Vicente-Rodríguez, Adoración Villarroya, Carlos M. Gil, Ignacio Ara, Juan Revenga, Carmen Lachen, Juan Fernández Alvira, Gloria Bueno, Aurora Lázaro, Olga Bueno, Juan F. León, Jesús Mª Garagorri, Manuel Bueno, Juan Pablo Rey López, Iris Iglesia, Paula Velasco, Silvia Bel

Consejo Superior de Investigaciones Científicas (Spain)

Ascensión Marcos, Julia Wärnberg, Esther Nova, Sonia Gómez, Esperanza Ligia Díaz, Javier Romeo, Ana Veses, Mari Angeles Puertollano, Belén Zapatera, Tamara Pozo

Université de Lille 2 (France)

Laurent Beghin, Christian Libersa, Frédéric Gottrand, Catalina Iliescu, Juliana Von Berlepsch

Research Institute of Child Nutrition Dortmund, Rheinische Friedrich-Wilhelms-Universität Bonn (Germany)

Mathilde Kersting, Wolfgang Sichert-Hellert, Ellen Koeppen

Pécsi Tudományegyetem (University of Pécs) (Hungary)

Dénes Molnar, Eva Erhardt, Katalin Csernus, Katalin Török, Szilvia Bokor, Mrs. Angster, Enikö Nagy, Orsolya Kovács, Judit Répasi

University of Crete School of Medicine (Greece)

Anthony Kafatos, Caroline Codrington, María Plada, Angeliki Papadaki, Katerina Sarri, Anna Viskadourou, Christos Hatzis, Michael Kiriakakis, George Tsibinos, Constantine Vardavas Manolis Sbokos, Eva Protoyeraki, Maria Fasoulaki

Institut für Ernährungs- und Lebensmittelwissenschaften – Ernährungphysiologie. Rheinische Friedrich Wilhelms Universität (Germany)

Peter Stehle, Klaus Pietrzik, Marcela González-Gross, Christina Breidenassel, Andre Spinneker, Jasmin Al-Tahan, Miriam Segoviano, Anke Berchtold, Christine Bierschbach, Erika Blatzheim, Adelheid Schuch, Petra Pickert

University of Granada (Spain)

Manuel J. Castillo Garzón, Ángel Gutiérrez Sáinz, Francisco B. Ortega Porcel, Jonatan Ruiz Ruiz, Enrique García Artero, Vanesa España Romero, David Jiménez Pavón, Cristóbal Sánchez Muñoz, Victor Soto, Palma Chillón, Jose M. Heredia, Virginia Aparicio, Pedro Baena, Claudia M. Cardia, Ana Carbonell, Magdalena Cuenca-García

Istituto Nazionalen di Ricerca per gli Alimenti e la Nutrizione (Italy)

Davide Arcella, Giovina Catasta, Laura Censi, Donatella Ciarapica, Marika Ferrari, Cinzia Le Donne, Catherine Leclerq, Luciana Magrì, Giuseppe Maiani, Rafaela Piccinelli, Angela Polito, Raffaela Spada, Elisabetta Toti

University of Napoli 'Federico II' Dept of Food Science (Italy)

Luca Scalfi, Paola Vitaglione, Concetta Montagnese

Ghent University (Belgium)

Ilse De Bourdeaudhuij, Stefaan De Henauw, Tineke De Vriendt, Lea Maes, Christophe Matthys, Carine Vereecken, Mieke de Maeyer, Charlene Ottevaere, Inge Huybrechts

Medical University of Vienna (Austria)

Kurt Widhalm, Katharina Phillipp, Sabine Dietrich

Harokopio University (Greece)

Yannis Manios, Eva Grammatikaki, Zoi Bouloubasi, Tina Louisa Cook, Sofia Eleutheriou, Orsalia Consta, George Moschonis, Ioanna Katsaroli, George Kraniou, Stalo Papoutsou, Despoina Keke, Ioanna Petraki, Elena Bellou, Sofia Tanagra, Kostalenia Kallianoti, Dionysia Argyropoulou, Katerina Kondaki, Stamatoula Tsikrika, Christos Karaiskos

Institut Pasteur de Lille (France)

Jean Dallongeville, Aline Meirhaeghe

Karolinska Institutet (Sweden)

Michael Sjöstrom, Patrick Bergman, María Hagströmer, Lena Hallström, Mårten Hallberg, Eric Poortvliet, Julia Wärnberg, Nico Rizzo, Linda Beckman, Anita Hurtig Wennlöf, Emma Patterson, Lydia Kwak, Lars Cernerud, Per Tillgren, Stefaan Sörensen

Asociación de Investigación de la Industria Agroalimentaria (Spain)

Jackie Sánchez-Molero, Elena Picó, Maite Navarro, Blanca Viadel, José Enrique Carreres, Gema Merino, Rosa Sanjuán, María Lorente, María José Sánchez, Sara Castelló

Campden BRI (United Kingdom)

Chantal Gilbert, Sarah Thomas, Elaine Allchurch, Peter Burguess

SIK – Institutet foer Livsmedel och Bioteknik (Sweden)

Gunnar Hall, Annika Astrom, Anna Sverkén, Agneta Broberg

Meurice Recherche & Development asbl (Belgium)

Annick Masson, Claire Lehoux, Pascal Brabant, Philippe Pate, Laurence Fontaine

Campden & Chorleywood Food Development Institute (Hungary)

Andras Sebok, Tunde Kuti, Adrienn Hegyi

Productos Aditivos SA (Spain)

Cristina Maldonado, Ana Llorente

Cárnicas Serrano SL (Spain)

Emilio García

Cederroth International AB (Sweden)

Holger von Fircks, Marianne Lilja Hallberg, Maria Messerer

Lantmännen Food R&D (Sweden)

Mats Larsson, Helena Fredriksson, Viola Adamsson, Ingmar Börjesson

European Food Information Council (Belgium)

Laura Fernández, Laura Smillie, Josephine Wills

Universidad Politécnica de Madrid (Spain)

Marcela González-Gross, Agustín Meléndez, Pedro J. Benito, Javier Calderón, David Jiménez-Pavón, Jara Valtueña, Paloma Navarro, Alejandro Urzanqui, Ulrike Albers, Raquel Pedrero, Juan José Gómez Lorente

British Journal of Nutrition