Chapter 14

Diet Quality Indices for Nutrition Assessment: Types and Applications

Maria Luisa Poyatos Guerrero and
Fernando Pérez-Rodríguez

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.69807

Abstract

According to the World Health Organization, the proportion of noncommunicable diseases (NCD) burden is foreseen to increase to 57% in 2020. Consumption patterns have a positive effect on healthy growth and development during childhood and adolescence, and on health problems in adulthood. Diet quality indices are mathematical algorithms used for nutritional epidemiology, aimed at quantifying the degree of adequacy between actual intakes of nutrients or food groups within a population and the reference intakes, which are established based on scientific facts assuring an optimal state of health while preventing consumers from chronic diseases. Similarly, indexes allow to analyse dietary pattern of target population and its consumption trends. In general the terms, DQI (Diet Quality Index), HDI (Healthy Diet Indicator) and MDS (Mediterranean Diet Score), are referred to three internationally recognized diet indexes, which several indices have been adapted from. This chapter includes an extensive review of existing diet indexes, 1) providing a brief description of the most relevant ones, 2) highlighting the weaknesses and strengths and 3) defining the suitable scope of application of each index.

Keywords: diet quality, dietary quality index, food habits, lifestyles, diet variety

1. Introduction

According to the World Health Organisation, the burden of chronic diseases is rapidly increasing worldwide. In 2001, chronic diseases accounted for around 60% of the total reported deaths in the world and 46% of the global burden of disease [1]. Almost half of total chronic disease deaths are attributable to cardiovascular diseases. Obesity and diabetes are also showing worrying trends, not only because they already affect a large proportion of the population, but also because they have started to appear earlier in life [2]. The relevance of diet quality in the prevention and management of disease and premature death caused by noncommunicable diseases (NCDs) is scientifically supported by epidemiological data. Eating patterns may have a positive impact on healthy growth and development throughout childhood and adolescence [3], and on the mitigation of health problems in adults [4].

However, "diet quality" remains a somewhat imprecise term, due to the heterogeneous and multidimensional nature of the concept itself, whose definition should ideally reflect aspects relevant to a number of fields, including nutrition, toxicology, economics and the food industry [5]. Although consensus has yet to be reached on the concept, a high-quality diet may be defined as one which is hygienically safe; nutritious and balanced and adapted to individual requirements in order to prevent disease and ensure a good state of health as well as optimal development and growth [6].

Methods for assessing diet quality have attracted growing interest since Patterson published the first dietary quality index in 1994 [7]. While the concept itself is undoubtedly heterogeneous and multidisciplinary, dietary quality indices (DQIs) are no more than mathematical algorithms aimed at quantifying the extent to which real food and nutrient intake complies with the reference intake values recommended in national dietary guidelines, or at analysing dietary patterns in the population and weighting those components whose consumption has been linked, in scientific studies, either to the appearance of the disease or to the preservation of an optimal state of health [8].

In the first global review of DQIs, published in 1996, Kant assigned each index to one of three groups depending on the items it comprised [9]:

Indices based solely on an analysis of nutrient intake. Examples include the index developed by Cusatis et al. for use as a tool in the Penn State Young Women's Health Study [10].

1.1. Indices based on food groups

Indices based on a combination of food groups and nutrient intake. This is the most widespread approach, given that—since people do not consume foods or nutrients singly—research into the potential link between food/nutrient intake and disease should focus not on a single food or nutrient but rather on the diet as whole [9].

Later, in 2015, Gil defined a new category: indices comprising items intended to assess a range of specific behaviour patterns: eating habits, physical activity and rest, and certain sociocultural or lifestyle habits. Gil labelled these items "healthy lifestyle indicators" (HLIs) [8].

Dietary quality indices traditionally focused on the extent to which real dietary intake complied with nutritional recommendations, and on variations in the intake of basic food groups [9]; current indices tend to include additional items relating to life style and physical exercise [8].

2. Reference values: ideal consumption of food groups or nutrients

There is clear disagreement regarding the servings or amounts of different food/nutrient groups that should ideally be consumed. The determination of nutritional needs is a complex matter. Each country, drawing on the findings of expert groups, has issued its own recommendations, reflecting the characteristics of the population, specific recommendations are made for target groups as a function of age, sex and physiological status (e.g. pregnant or breastfeeding women). Recommendations are also taken into account the extent to which a given nutrient is used, its bioavailability, the existence of precursors, potential interactions with other substances [11] and potential loss or alteration during food transport, storage, processing and preparation [12]. According to Bolzetta, the factors to be borne in mind when establishing the Recommended Intake (RI) values for essential nutrients, which scientific research has shown to be sufficient to meet the nutritional needs of practically all healthy people, can be divided into three major categories [13]:

1. Person-related factors, that is, those which govern inter-individual variability.
2. Environment-related factors.
3. Diet-related factors, that is, those linked to food intake.

On this basis, the Food and Nutrition Board of the American Institute of Medicine (FNB-IOM) established Dietary Reference Intakes (DRIs) for North America (United States and Canada) comprising a number of parameters such as estimated average requirement (EAR), recommended dietary allowances (RDA), adequate intake (AI) and tolerable upper intake level (UL). These guidelines, which replaced the RIs in force until 1997, provide reference values for the nutrients that a diet should contain in order to prevent deficiency diseases, reduce the burden of chronic disease and achieve optimal health by making maximum use of each nutrient. If there is sufficient confirmed scientific evidence, an EAR[1] is set; this value, after further testing, shall be considered as RDA.[2] If testing is inconclusive, an estimated value is provided, known as the IA.[3] When sufficient data is available, ULs[4] are also established for nutrients. Since these values are not readily understood by the layman, they are used as the basis for Food-Based Dietary Guidelines (FBDG) which express nutrient requirements in the form of servings of different food groups; the language used is straightforward and the information is often additionally expressed graphically, for example, in the form of a pyramid, a diamond-shape or a wheel. The most commonly used graphic worldwide was the pyramid: foods to be consumed most frequently were placed at the base, and foods

[1]EAR, estimated average requirement: a nutrient intake value that is estimated to meet the requirement of half the healthy individuals in a group of people of a given age and sex.
[2]RDA, recommended dietary allowances: the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97–98%) healthy individuals in a group of people of given age and sex.
[3]AI, adequate intake, a value based on observed or experimentally determined approximations of nutrient intake by a group (or groups) of healthy people—used when an RDA cannot be determined.
[4]UL, tolerable upper intake level: the highest level of daily nutrient intake that is likely to pose no risk of adverse health effects to almost all individuals in the general population.

to be avoided or consumed only occasionally at the apex [14]. In 2011, the United States Department of Agriculture (USDA) replaced the pyramid with a simpler design, where the proportions of the different food groups to be consumed in the course of the day are shown as servings on a plate. “My plate” promotes fruit and vegetables, which together occupy half the plate; grains and proteins each occupy a quarter of the plate. Dairy products are present in the form of a glass of milk beside the plate [15].

Although the Dietary Guidelines for Americans—published every 5 years since 1980, and now in their eighth edition (2015–2020), accompanied since 1992 by a pyramid graphic—have long served as an international benchmark, several countries have developed their own guidelines, taking into account specific national dietary requirements. Most national guidelines advocate greater variety in the diet, increased intake of plant-based foods—especially fruit and vegetables—and lower consumption of solid fats, salt and sugar [16, 17].

3. Methods for collecting food consumption data

Consumption data provide the essential basis for any assessment of nutritional status and for the drawing up of nutritional guidelines for the population as a whole. The type of application for which data are used is largely determined by the method of collection, which also accounts for certain limitations.

Since 1940, FAO has regularly published national food balance sheets, which provide data on food potentially available for human consumption during a specified reference period. The balance sheets provide a picture of the overall food supply situation in a country, but give no indication of the diet consumed by different population groups depending on their socioeconomic status or geographical location; or do they provide information on seasonal variations in food consumption (i.e. the distribution of national consumption at different times of year) [18, 19].

Household surveys are bound by the same constraints. Available foods are weighed at the beginning and end of the reference period; any incoming food is added daily to the supply figure, while any food consumed other than by the survey participants is subtracted. The total amount of food consumed by the household over the period is then divided equally between its members. While certain survey groups tend to be fairly homogeneous—for example, school dining-rooms or old people’s room—the composition of a household may vary considerably. Such surveys thus provide an overall view of the group, but do not record the real intake of each household member. However, they do enable identification of groups at risk due to inappropriate intake, which require closer investigation.

Individual dietary surveys can be carried out prospectively, that is, studying current intake, or retrospectively, focussing on past intake. Most dietary quality indices (DQIs) are based on retrospective studies, since these enable measurement of intake in the immediate, recent or distant past, and also provide data for epidemiological studies, by relating past diet to present disease. The main limitation is that data collection requires participants to remember their past diet and their reports may be influenced by their current diet [19]. The respondent’s diet history may comprise various sections and may take several forms:

1. Record of food consumed over 2 or 3 days or, failing this, a 24 h-food recall, in order to gain an idea of diet type and eating habits [20].

2. Food frequency questionnaire (daily, weekly and monthly) covering the last month. This is a structured, organised list, broken down by meals: breakfast, lunch and dinner (first course, second course and dessert). The amount consumed is estimated by approximate measurement at home or by reference to photograph collections showing different serving sizes of the same food or dish [21].

3. Specific questions relating to the study aims.

4. Dietary quality index applications

DQIs can be classed depending on their application, as health assessment indices or risk assessment indices. Health assessment indices focus on dietary quality in terms of compliance with dietary guidelines, and thus provide a practical way of assessing the health status of the population. The findings can be used to draw up specific effective prevention strategies. Indices of this type include, for example, those designed to assess compliance with the Mediterranean diet, whose consumption by various groups has been associated with lower rates of chronic disease, myocardial infarction, arthritis, various neoplasms (including breast, bowel and prostate cancers), diabetes, other oxidative-stress-related pathologies, childhood asthma and rhinitis. When repeated at intervals, the findings of such indices can be used to chart changes in eating patterns and to compare dietary quality in different groups and populations, thus providing a useful basis for the design of nutritional intervention policies. Risk assessment indices measure the risk of developing certain diseases, by examining overall diet composition and nutrient intake. A number of indices have been used, for example, to investigate cardiovascular risk and cancer mortality [22–27].

Kant was the first to review global diet quality indices, noting that—not unexpectedly—the definition of diet quality depended on attributes selected by the investigators [9]. In a second review, published 8 years later, she reviewed the literature on dietary patterns, both empirically derived and theoretically defined—in relation to health outcomes [28]. Later, Waijers et al. reviewed 20 DQIs, and found that existing indices did not predict disease or mortality significantly better than individual dietary factors, although they may be useful for measuring the extent to which individuals adhere to dietary guidelines [29]. Arvaniti and Panagiotakos also reviewed 23 DQIs, most of which overlapped with those reported by Waijers [30]. Bach et al. revised a number of DQIs developed for the general adult population based on the Mediterranean diet and their correlation with health outcomes [31]. More recently, Alkerwi highlighted the complexities involved in defining and quantifying the concept of *diet quality*, and recommended an integrated approach that combines not only nutritional characteristics but also other facets of diet quality, including food safety, organoleptic and sociocultural aspects for which there are currently no established thresholds or criteria, with a view to dispelling the confusion generated by multiple DQIs [4]. Similarly, in 2015 Gil hailed DQIs as an important tool for assessing diet quality within specific populations, in terms not only of nutrient intake but also of diversity and moderation, although advocating a more global concept taking into account, in addition to food groups and nutrients, factors such as certain sociocultural habits, physical activity, sedentariness and rest create healthy lifestyle indicators (HLIs) [8].

Other reviews have focused on the use of indices in children: in 2011, Lazarou and Newby [32] examined 90 indices used in developed countries, while in 2014 Marshall et al. [33] conducted a similar review at world level. Both acknowledged the value of dietary indices, regardless of the individual methodology used but noted that, in general, higher *diet-quality* scores were associated with more favourable nutrient and food intakes, better lifestyles, lower chronic disease risk factors, more favourable body composition, less obesity and fewer asthma-related conditions. However, certain measures or techniques used in data processing need to be more clearly defined in order to increase the robustness of estimations regarding diet quality.

5. Main dietary indexes

The first Diet Quality Index, published by Patterson in 1994, was based on an epidemiological study analysing the diet of 5484 adults in the United States. Her index comprised eight items, six of which related to specific nutrients (total fat, saturated fatty acids (SFA), cholesterol, protein, sodium and calcium), while the remaining two assessed only intake of food groups (fruit and vegetables, grain and legumes). She found that low index scores correlated positively with vitamin and mineral intake, and negatively with fat intake [7].

Taking this index as a basis, Haines et al. [34] produced the Diet Quality Index Revised (DQI-R), which sought to reflect subsequent changes in the recommendations for the American population. The major new feature was the incorporation of dietary diversity and moderation as specific items. Diversity was scored using 23 subcategories of the 4 food-group categories established in the Food Guide Pyramid: 7 for grains, 7 for vegetables, 2 for fruits and 7 for meat/dairy components. Diversity was recorded over two survey days. Moderation was measured in terms of added sugars, discretionary fat, sodium intake and alcohol intake. Scoring criteria were taken from the Food Guide Pyramid and adjusted for Kcal intake per individual; AI was used for calcium and RDA for iron [34]. The index thus analysed both nutrient and food-group intake. The most recent review was published by Fung in 2005 [35].

In 1995, the United States Department of Agriculture (USDA) published the Healthy Eating Index (HEI), designed by Kennedy et al. with a view to monitoring changes in the quality of American diets and to developing and evaluating nutritional intervention strategies [36]. The original index comprised 10 variables covering nutrient intake, food-group intake and dietary variation. The first five items were based on the five major food groups included in the American Food Guide Pyramid (1992), which was later replaced by MyPyramid (2005) [37]: grains, vegetables, fruits milk and meat. A further four items (fat, SFA, cholesterol and sodium) reflected the intake values recommended by national dietary guidelines. The tenth item, dietary variety, was a measure of the variety in food choices, scored as intake of 16 items over an arbitrary 3-day period. Each item was a discrete variable scored from 0 to 10, giving a maximum HEI score of 100 points. Two subsequent revisions were carried out by Guenther et al. (HEI-2005) [38] and in 2010 (HEI-2010) [39], which included an additional food group item—fish and seafood—in the design. The revised versions comprised 12 components, and additionally evaluated energy density, adequacy and dietary moderation.

Using the variety component of the original HEI designed by Kennedy et al. [36], Cox et al. developed the Food Variety Index for Toddlers (VIT) to assess diet in children aged between 24 and 36 months. Ideal intake for each food item was as given in the Food Guide Pyramid, adapted for this age range [40].

Feskanich et al. also used the HEI as the basis for assessing diet quality in children aged 9–14 whose parents were participants in US Nurses Health Study II cohort. The resulting Young Healthy Eating Index (YHEI) includes both eating habits and intake of food groups associated with "empty calorie" intake. The Index comprises 13 items. The first 7 items (intake of wholemeal grains, vegetables, fruits, dairy products, meat, snacks and soft drinks) have a maximum score of 10, while the remaining 6 (intake of multivitamins, margarine and butter, fried foods outside the home, visible animal fat, eating breakfast and dinner with parents) had a maximum of 5 points. The score for the overall Index thus ranged from 0 to 100. The HEI score was highly correlated with total energy intake ($r = 0.67$), and as inversely associated with time spent in inactive pursuits ($r = -0.27$) [41].

Huijbregts et al. were the first to devise a method for simplifying calculations and extracting total scores from an index. Using the World Health Organisation (WHO) guidelines for the prevention of chronic diseases, they conducted a longitudinal cohort study of a random sample of men aged between 1950 and 1970 in 1970; a total of five cohorts were followed up in Finland, Italy and the Netherlands. Findings were used to develop the Healthy Diet Indicator (HDI) [42], in which a dichotomous variable was generated for each food group or nutrient that was included in the WHO guidelines, thus making calculation easier than in earlier indices. If a person's intake was within the recommended range this variable was coded as 1; otherwise it was coded as 0. The HDI was the sum of values for nine variables: SFA, polyunsaturated fatty acids (PUFA), cholesterol, protein, complex carbohydrates, monosaccharides and disaccharides, dietary fibre, fruits and vegetables, pulses, nuts and seeds. The overall score therefore ranged between 0 and 9. Although we still assess nutrient and food group intake, the HDI did so in a more specific manner than earlier indices. Instead of evaluating total fat intake, its origin was taken into account, whit the result that a single item in earlier studies (total fat) was broken down into three items (SFA, PUFA and cholesterol), enabling more detailed analysis. A further modification was the assessment of dietary fibre intake and nut intake as separate components.

Later, in order to compare diet quality between populations with different eating habits and evaluate their current stage of nutrition transition, Kim et al. developed the Diet Quality Index-International (DQI-I), which was initially applied to China and the United States [43]. The DQI-I focused on three major aspects of diet: adequacy, moderation and overall balance, and total index scores ranged from 0 to 100. A new feature was the assessment of Vitamin C intake. Other items were similar to those used in the DQI-R, although scoring was completely different and somewhat arbitrary, as shown in **Table 1**. Within the block of items assessing dietary moderation, the alcohol item was included under "empty calories". Since European countries follow the Mediterranean diet, and well-known characteristic variables for the European region were not taken into account in designing this index, the DQI-I was modified by Tur et al. to assess diet quality in Andalusia: fat intake guidelines were increased by 10% for the Mediterranean region, largely to reflect olive oil consumption [44].

Variety	**0–20 points**	
Overall food group variety (meat/poultry/fish/eggs; dairy/beans; grain; fruit; vegetable)	>1 serving from each food group/day	15 points
	Any 1 food group missing/day	12 points
	Any 2 food groups missing/day	9 points
	Any 3 food groups missing/day	6 points
	>4 food groups missing/day	3 points
	None from any food groups	0 points
Within-group variety for protein source (meat, poultry, fish, dairy, beans, eggs)	>3 different sources/day	5 points
	Two different sources/day	3 points
	From 1 source/day	1 points
	None	0 points
Adequacy	0–40 points	
Vegetable group	3–5 servings/day	5 points
	0 servings/day)	0 points
Fruit group	2–4 servings/day	5 points
	0 servings/day	0 points
Grain group	6–11 servings/day	5 points
	0 servings/day	0 points
Fibre	20–30 g/day	5 points
	0 g/day	0 points
Protein	10% of energy/day	5 points
	0% of energy/day	0 points
Iron	100% RDA (AI)/day	5 points
	0% RDA (AI)/day	0 points
Calcium	100% AI/day	5 points
	0% AI/day	0 points
Vitamin C	100% RDA (RNI)/day	5 points
	0% RDA (RNI)/day	0 points
Moderation	0–30 points	
Total fat	<20% of total energy/day	6 points
	20–30% of total energy/day	3 points
	>30% of total energy/day	0 points
Saturated fat	>7% of total energy/day	6 points
	7–10% of total energy/day	3 points
	10% of total energy/day	0 points

http://dx.doi.org/10.5772/intechopen.69807

Variety	0–20 points	
Cholesterol	<300 mg/day	6 points
	300–400 mg/day	3 points
	>400 mg/day	0 points
Sodium	<2400 mg/day	6 points
	2400–3400 mg/day	3 points
	>3400 mg/day	0 points
Empty calorie foods	<3% of total energy/day	6 points
	3–10% of total energy/day	3 points
	>10% of total energy/day	0 points

Table 1. Scoring and items included in the Diet Quality Index international (DQI).

6. Indices for the Mediterranean diet

The Seven Countries Study carried out by Dr Ancel Keys from 1958 onwards was the first to systematically examine the links between diet, lifestyle, risk factors and rates of coronary disease and cerebrovascular accident [45]. A total of 12,763 men aged between 40 and 59 were recruited into 16 cohorts in 7 different countries: Finland, Italy, Netherlands, Greece, Yugoslavia, United States and Japan. Participants were given standardised tests relating to lifestyles and cardiovascular risk factors: they were tested at the start of the study (baseline data) and then after 5 and 10 years' follow-up.

One major conclusion of the study was that cardiovascular diseases can be prevented and are strongly influenced by the fatty composition of the habitual diet. The study also suggested that there may be other and important protective elements in the diet and lifestyles of Crete and Japan [46]. The healthy nature of the Greek diet and more particularly the Cretan diet moved Keys to label it the Mediterranean Diet and to note that it is characterised by high intake of fruit and vegetables, pulses, nuts and grains and, especially, olive oil, together with moderate consumption of fish, eggs and dairy products—preferably yoghurt and cheese—and lower intakes of meats and animal fats [47].

It is regarded as the prototype of a healthy diet, since it ensures a supply of calories and nutrients in sufficient amounts and adequate proportions, and also contributes to the prevention of cardiovascular disease, hypertension, diabetes and cancer, and generally to increased life expectancy [48–54].

In view of its many benefits, numerous indices have been designed to assess compliance with this diet. The original Mediterranean Diet Score (MDS) was developed by Trichopoulou et al. to assess adherence to the Mediterranean diet consumed by the Greek population, in view of the apparent beneficial effects of this diet on health and longevity [55]. The MDS comprised eight components: seven food groups (vegetables, legumes, fruit and nuts, dairy products, cereals, meat and meat products and alcohol) and the MUFA:SFA ratio. A value of 0 or 1 was assigned to each item, using the median value for each sex as a cut-off point. The total score thus ranged from 1 to 8. A value of 1 was assigned for a daily intake of 10-50g of alcohol for men and 5-25 g of alcohol for women. In general terms, a score of 4 or more was taken to indicate satisfactory compliance. Food frequencies were adjusted to daily intakes of 2500 kcal for men and 2000 kcal for women, so estimations reflected variations in median energy intake. A later revision by Trichopoulou et al. included a ninth item—fish intake—bringing the total maximum score to 9 [56]. The MDS index has been widely used in studies relating the Mediterranean diet to disease, in some cases incorporating modifications to reflect the specific purpose of the study. Bach et al. have reviewed studies applying MDS or variations of it [31]. One limitation of this index is the use of median intake for the population as a cut-off point, rather than the intake deemed suitable for that population. To address this issue, Schröder et al. developed a rapid 14-point screening questionnaire, the Mediterranean Diet Adherence Screener (MEDAS) for assessing adherence to the Mediterranean diet [57]. Twelve items related to food consumption frequency, and the remaining two food intake habits are considered as characteristic of the Spanish Mediterranean diet. Each question was scored 0 or 1, so that overall scores ranged from 0 to 14. A score of less than 9 was considered indicative of poor adherence, and a score of more than 9 indicative of satisfactory adherence. This index was used in the 2013 PREDIMED Prevention with Mediterranean Diet (PREDIMED) study [58]. The criterion used are set out in **Table 2**.

One variant is the KidMed index used in the "enKid" study to assess adherence to the Mediterranean diet in younger age groups. It was developed in 2003 to evaluate the eating habits of 3850 Spanish children, adolescents and young adults (age 2–24) [59]. The questionnaire com-

Olive oil as the principal source of fat for cooking	+1
Four or more tablespoons—1 tablespoon 13.5 g— of olive oil/day (including that used in frying, salads, meals eaten away from home)	+1
Two or more serving of vegetables/day	+1
Three or more pieces of fruit/day	+1
<1 Serving of red meat or sausages/day	+1
<1 Serving of animal fat/day	+1
<1 Cup (1 cup = 100 ml) of sugar-sweetened beverages/day	+1
Seven or more servings of red wine/week	+1
Three or more servings of fish/week	+1
Three or more serving of nuts/week(30g/serving)	+1
<2 Commercial pastries/week	+1
Three or more pieces of fruit/day	+1
Two or more servings/week of a dish with a traditional sauce of tomatoes, garlic, onion, or leeks sautéed in olive oi.	+1
Preferring white meat over red meat	+1

Table 2. Scoring and items included in the Mediterranean Diet Adhere Screener (MEDAS).

prises 16 items: affirmative responses to questions denoting a negative connotation with regard to the Mediterranean diet were assigned a value of −1, while affirmative responses to questions denoting a positive connotation were assigned a value of +1. The scoring range for the index was therefore from 0 to 16. For purposes of interpretation, the sum of the values were classified into three levels: ≤3—very low diet quality; from 4 to 7—improvement needed to adjust intake to Mediterranean patterns; ≥8—optimal Mediterranean diet (**Table 3**). A number of studies have used the KidMed index to assess diet quality in children and adolescents. More recent research using this index is reported by Toktas and Yildiz [60], Mistretta et al. [61] and Idelson et al. [62].

As indicated earlier, the Mediterranean diet involves more than just healthy eating habits. In order to benefit fully from the diet, a number of cultural and lifestyle elements need to be borne in mind: moderation in calorie intake; regarding eating as a social act in which the act of cooking the food to be eaten plays a major role; physical activity and rest. Awareness of these additional elements has led, over the last few years, to the development of healthy lifestyle indicators that focus on these variables as well as on food intake [63]. This more holistic approach gave rise to the Mediterranean Lifestyle Index (MEDLIFE), based on the current guidelines reflected in the Spanish Mediterranean diet pyramid: in the base, food items that should sustain the diet, with recommendations concerning the composition and serving size of main meals; in the upper levels, foods to be eaten in moderate amounts. But the pyramid also contains cultural and social elements characteristic of the Mediterranean way of life in a broader sense [64].

Takes a fruit or fruit juice every day	+1
Has a second fruit every day	+1
Has fresh or cooked vegetables regularly once a day	+1
Has fresh or cooked vegetables more than once a day	+1
Consumes fish regularly (at least 2–3 times per week)	+1
Goes more than once a week to a fast-food (hamburger) restaurant	−1
Likes pulses and eats them more than once a week	+1
Consumes pasta or rice almost every day (5 or more times per week)	+1
Has cereals or grains (bread, etc) for breakfast	+1
Consumes nuts regularly (at least 2–3 times per week)	+1
Uses olive oil at home	+1
Skips breakfast	−1
Has a dairy product for breakfast (yogurt, milk, etc.)	+1
Has commercially baked goods or pastries for breakfast	−1
Takes two yogurts and/or some cheese (40 g) daily	+1
Takes sweets and candy several times every day	−1

Table 3. Scoring and items used in KidMed of adherence to the Mediterranean diet for childhood.

The pyramid was used as the basis for the MEDLIFE index [65], which assess adherence to the Mediterranean lifestyle. MEDLIFE comprises 28 items covering 3 separate aspects of Mediterranean lifestyle: 15 items assess consumption of various food groups; 7 items focus on traditional Mediterranean eating habits and physical activity and the remaining 6 examine physical activity, rest and social interaction. Compliance with each item was assigned 1 point and incompliance 0 points scored. The total score for the index as a whole thus ranged from 0 to 28 points. The index is viewed as a more holistic tool to measure adherence to the Mediterranean lifestyle in epidemiological studies.

In line with this broad-based approach to lifestyle indices, the E-KINDEX developed by Lazarou et al. for use with children [66] comprises three blocks of items. The first block, designated Foods E-KINDEX, assesses intake of eight food-groups ensuring a varied diet (bread, cereals and grain foods, fruits and fruit juices, vegetables, legumes, milk, fish and meat); three additional items relate to cooking technique (smoked or salted meats, fried food, grilled food) and to others to empty calorie intake (sweets and snacks, and soft drinks). The second block, designated Dietary Behavior E-KINDEX consists of eight statements regarding the child's attitude to his own diet. The third and final block, labelled Dietary Habits E-KINDEX, comprises nine items designed to assess eating habits, for example, number of meals per day, meals eaten outside the home, eating alone or with parents. Scoring on the E-KINDEX ranges from 1 (the lowest) to 87 (the highest). This index is of particular interest, since in addition to actually quantifying diet quality and eating habits in the child, it detects potential problems of nutritional education through the questions in Block 2. For validation of the E-KINDEX, multiple linear and logistic regression analyses were applied, taking as dependent outcomes various body composition indices of 1140 children from the CYKIDS study, aged 9–13 [67]. In all models, adjustments were made for age, gender, physical activity level, TV viewing time, socioeconomic status, breastfeeding and parental obesity status. The highest E-KINDEX category (60 points) was associated with 85% less likelihood of a child being obese or overweight and 86% less likelihood of having a waist circumference ≥ 75th percentile.

Another index used to assess children's lifestyle is the Preschoolers Diet-Lifestyle Index (PDL-Index) designed by Manios et al. [68] and validated using a sample of 2287 Greek preschool children (from the GENESIS study). The index comprises 11 items: fruits, fish and seafood, sweets, grains, unsaturated fats, vegetables, red meat and meat products, white meat and legumes, dairy products, physical activity and hours of TV viewing. The scoring interval for each item was from 0 to 4, so the total index score ranged from 0 to 44. In the absence of dietary guidelines for preschool children in Greece, components were selected on the basis of the USDA's Food Guide Pyramid, Canada's Food Guide, and the dietary recommendations of the American Heart Association and the American Academy of Pediatrics (AAP). Higher scores indicated greater adherence to dietary-lifestyle guidelines. Overweight and obese children are more likely to have cardiovascular disease risks (hypertension, type 2 diabetes mellitus) and to be overweight or obese as adults [68, 69].

7. Variety as a criterion for dietary quality in childhood

As indicated in earlier sections, most current diet quality indices were developed for the adult population and based on US dietary guidelines (**Figure 1**). Many have subsequently

http://dx.doi.org/10.5772/intechopen.69807

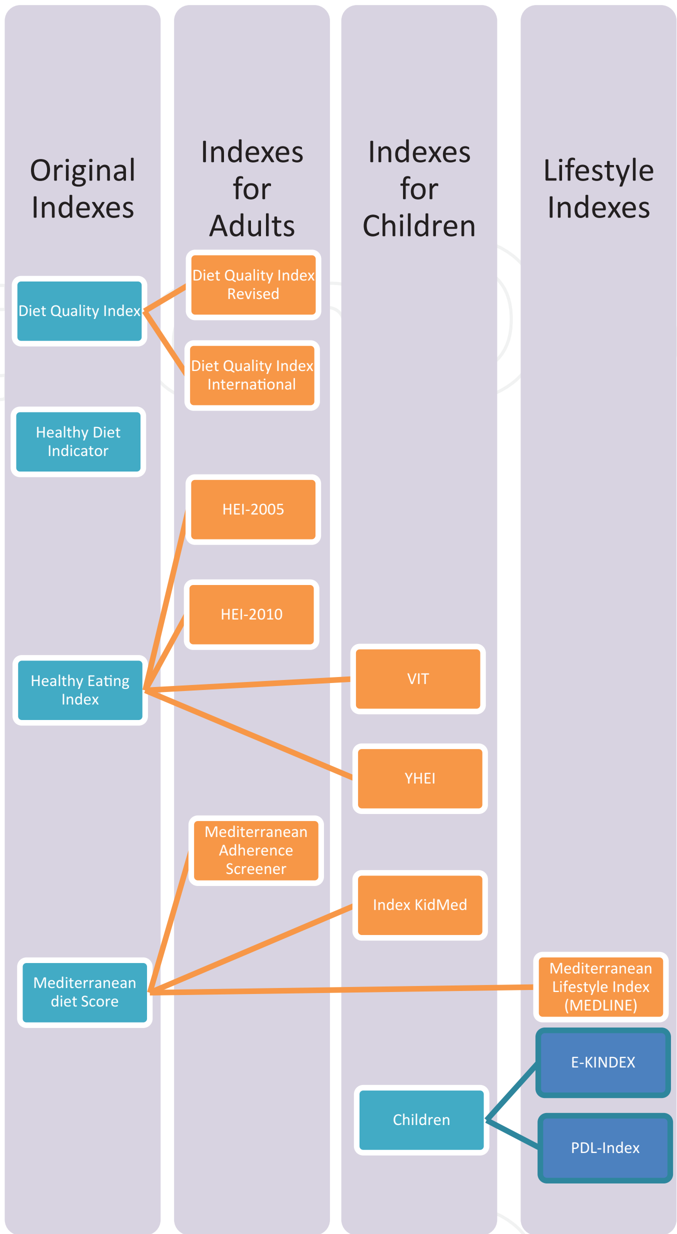

Figure 1. Scheme representing the relationship between original and revised Diet Quality/Lifestyle Indexes for Adults and Children.

been developed or modified for use with children and adolescents in the United States (age 2–18) [70–73], Australia (age 4–16) [73–75], Germany (age 0–17) [76–78], Finland (age 1–6) [79], Spain (age 2–24) [80–82], Canada (age over 3) [83, 84] and a number of Asian countries [85, 86]. The scoring for these indices was based on the assumption that a diet containing an adequate variety of food groups was equally adequate in nutritional terms [86–89]. The items contained in the indices are often arbitrary, reflecting the importance of regional foodstuffs. examples include INCAP Papers Dietary Diversity Score [90], Saibul's Food Variety Score for indigenous Malaysians [91] and Roche's 2008 Dietary Diversity Score (DDS) for the Awajun in the Peruvian Amazon [92]. In some cases, no explanation is given for food classifications [93–95]. Some studies refer to country-specific guidelines, including the New Zealand Diet

Quality Index for Adolescents (NZDQI-A) [96, 97], the Chinese Children Dietary Index developed by Cheng et al. in 2013 to assess calorie intake in children and adolescents with reference to Chinese Dietary Guidelines and the dietary reference intakes (DRIs) for Chinese [85, 86].

The DDS most widely used to assess diet quality in children in developing countries are based on the diet quality surveys designed by Arimond et al. 2004 [88] to assess dietary diversity and nutritional status in children from 11 developing countries (Benin, Cambodia, Colombia, Ethiopia, Haiti, Malawi, Mali, Nepal, Peru, Rwanda and Zimbabwe) using the seven food groups included in the MEASURE DHS surveys [98]: (1) starchy staples (foods made from grains, roots or tubers); (2) legumes; (3) dairy products (milk other than breast milk, cheese or yoghurt); (4) meat, poultry, fish or eggs; (5) vitamin A-rich fruits and vegetables (pumpkin; red or yellow yams or squash; carrots or red sweet potatoes; green leafy vegetables; fruits such as mango, papaya or other local vitamin A-rich fruits); (6) other fruits and vegetables (or fruit juices) and (7) foods made with oil, fat or butter. Food/food groups that the child had consumed regularly received a score of 1 and those who did not consume regularly received a score of 0. Dietary diversity was assessed over an arbitrary 3-day period, and terciles of dietary diversity were used to classify children into low, average and high diversity. The findings suggested an association between child dietary diversity and nutritional status that is independent of socioeconomic factors, and that dietary diversity may indeed reflect diet quality.

Minor modifications were subsequently introduced to adapt these DDS to different research purposes. In 2007, Kennedy et al. [86] developed a variant to examine the correlation between dietary diversity and micronutrient intake. Ten food groups were used to calculate DDS: cereals and tubers; meat, poultry and fish; dairy; eggs; pulses and nuts; vitamin A-rich fruits and vegetables; other fruit; other vegetables; oils and fats and other). The choice of the 10 food groups was based on the outcome of discussions held during a workshop on validation methods for dietary diversity held in Rome, Italy in October 2004 [98]. Modifications with regard to the original included the separation of fruits and vegetables, the treatment of eggs as a separate item, and the addition of a group of “others” consisting of sugar, non-juice or dairy beverages, and condiments and spices. Data collection covered a 24-h period. An all inclusive DDS was calculated without a minimum intake for the food group. A second DDS was calculated applying a 10-g minimum intake for all food groups (DDS 10 g) except fats and oils.

Using Kennedy’s 10 g consumption criterion, in 2004 Moursi et al. [99] developed 4 variations on the DDS to study dietary diversity in 1667 children aged between 6 and 23 months in the districts of Sahalava and Antsororokavo, Fianarantsoa, Madagascar, as part of the Nutrimad project [100], and to confirm statistically the correlation between intake of 10 g of each food group and dietary micronutrient density. Two DDS (DDS8 and DDS8-R) covered a total of eight possible food groups: grains, roots and tubers; legumes and nuts; dairy products; flesh foods (meat, fish, poultry and liver/organ meats); eggs; vitamin A-rich fruits and vegetables (>130 retinol equivalents/100 g); other fruits and vegetables; and fats and oils. A score of 1 was assigned if a child ate 1 or more foods from a given food group and 0 if not. For DDS8-R, a food group was counted only if at least 10 g were consumed, except for fats and oils, for which the cut-off of ≥1 g was used. Two additional scores were calculated after excluding the fats and oils group (DDS7 and DD7-R) using the 1 g and 10 g minimum cut-offs (range 0–7).

All DDS scores correlated positively with dietary micronutrient density. These results support the growing evidence of the usefulness of dietary diversity to predict dietary quality, and among infants and young children more specifically.

8. Dietary Quality Index Items

Generally speaking, most indices include fruit and vegetables, and grains or cereals, as food groups. However, the criteria used for their classification vary considerably. The DQI places fruits and vegetable in the same group, but treats wholemeal cereals as a separate item. DQI-R scores fruit separately from vegetables, but—unlike DQI, HEI, MDS and HDI—places grains in a single category, without treating wholemeal grains as a specific item. Although HDI does not treat cereals as a single group, it addresses this design defect by evaluating their intake in the form of nutrients, measuring complex carbohydrate, monosaccharide and disaccharide and fibre intake. HEI increases the number of food groups to be assessed, introducing milk, meat, cereals fruit and vegetables as separate components. In contrast to other indices, "Nuts" are treated as a specific category in HDI, but are grouped with fruits in MDS. Pulses and olive oil feature as items in MDS, similar to fish intake.

In terms of the nutrients assessed, the greatest disparity is in relation to the treatment of data on fat intake. DQI, DQI-I and DQI-R assess intake of total fat, saturated fate and cholesterol, while HDI addresses only intake of SFA and PUFA and MDS deals only with the MUFA:SFA ratio. Quantification of vitamin and mineral intake is arbitrary: although most indices include calcium and sodium, DQI-R is one of the few indices to include iron intake, and DQI-I is among the few to assess Vitamin C intake.

The disparity is even more marked in child-related dietary quality indices. These are based on food groups rather than nutrients, and there is little consensus regarding nomenclature. The E-Kindex, for example, separates bread intake from cereal intake, and also takes into account cooking techniques which may lead to harmful eating habits, such as consumption of fried foods, and of smoked or salted meats. The PDL-Index places white meat and vegetables in the same category, but treats fish as an independent component. Reflecting current lifestyle trends, most indices used to assess dietary quality in developed countries include items to evaluate empty calorie intake and time devoted to physical activity. By contrast, the DDS—aimed at developing countries—dispense with these variables to focus on food intake and, in all cases, food structure: starchy staples (foods made from grains, roots or tubers); legumes; dairy products (milk other than breast milk, cheese or yoghurt); meat, poultry, fish or eggs; vitamin A-rich fruits and vegetables (pumpkin; red or yellow yams or squash; carrots or red sweet potatoes; green leafy vegetables; fruits such as mango, papaya or other local vitamin A-rich fruits; other fruits and vegetables (or fruit juices)) and foods made with oil, fat or butter. However, some indices treat certain components separately: the DDS developed by Kennedy in 2006, for example, separates fish and eggs from the protein group.

The components used by each index are shown in **Table 4**.

Nutrients	
Total fat	DQI, DQI-R, DQI-I, HEI, HEI-2005
SFA	DQI, DQI-R, DQI-I, HEI, HEI-2005, HDI, MDQI, The Chinese Children Dietary Index
Ratio of MUFA or PUFA to SFA	DQI-I, MDS, MDS-f, MDS-a I, MDS-a III
PUFA	HDI, PDL-Index
Protein	DQI, DQI-I, HDI
Carbohydrate	DQI
Complex carbohydrates	DQI, HDI
(Cereal) fibre	DQI-I, HDI, The Chinese Children Dietary Index
Mono- and disaccharides	DQI, HDI
Sucrose o sucrose added	DQI-a I
Cholesterol	DQI, DQI-R, DQI-I, DQI-a I – III, HEI, HEI-2005, HDI,
Alcohol	MDS, MDS-f, MDS-a I, III, IV
Sodium	DQI, DQI-I, DQI-a II, HEI, HEI-2005
Calcium	DQI, DQI-R, DQI-I
Iron	DQI-R, DQI-I
Vitamin C	DQI-I
Vit A	The Chinese Children Dietary Index
Ratio of carbohydrates to protein to fat	DQI-I
Energy balance	The Chinese Children Dietary Index
Foods	
Fruit and vegetables	DQI, MDQI, MDS-a I, HDI, VIT, YHEI, DDS8, DDS Eneman
Fruits (and nuts)	DQI-R, DQI-I, HEI, HEI-2005, AHEI, MDS, MDS-f, MDS-a II – IV, HuSKY , NZDQI-A, E-KINDEX, PDL-Index, GINI-plus/LISA-plus Studies, KIDMED, DDS Mirmiram, DDS Kennedy, FVS Saibul, DDS Rah, DDS Torheim, DDS Steyn, The Chinese Children Dietary Index
Vegetables	DQI-R, DQI-I, HEI, HEI-2005, AHEI, MDS, MDS-f, MDS-a II – IV, NZDQI-A, HuSKY, UFCS, E-KINDEX, PDL-Index, GINI-plus/LISA-plus Studies, KIDMED, DDS Mirmiram, DDS Kennedy, DDS Rah, DDS Torheim, DDS Steyn, The Chinese Children Dietary Index
Legumes (and nuts and seeds)	MDS, MDS-f, MDS-a I–IV, HDI, E-KINDEX, PDL-Index, DDS Kennedy, DDS Rah, DDS8, DDS Eneman, DDS Torheim, DDS Steyn
Nuts (and soya)	MDS-a II, MDS-a III, The Chinese Children Dietary Index
(Whole) cereals or grains	DQI-R, DQI-I, HEI, HEI-2005, all MDS, VIT, YHEI, E-KINDEX, PDL-Index, KIDMED, DDS Mirmiram, DDS Kennedy, DDS Torheim, The Chinese Children Dietary Index

http://dx.doi.org/10.5772/intechopen.69807

Nutrients	
Meat (and meat products)	HEI, HEI-2005, MDS, MDS-f, MDQI, MDS-a I – IV, VIT, YHEI, NZDQI-A, E-KINDEX, PDL-Index, DDS Mirmiram, DDS Kennedy, FVS Saibul, DDS Rah, DDS8, DDS Eneman,, DDS Torheim , DDS Steyn, The Chinese Children Dietary Index
Eggs	DDS Kennedy, FVS Saibul, DDS8, DDS Eneman, DDS Torheim, DDS Steyn, The Chinese Children Dietary Index
White meat	PDL-Index
Red and processed meat	MDS-a III
Poultry	MDS-a IV, DDS Kennedy, FVS Saibul, DDS Rah, DDS8, DDS Eneman, DDS Steyn
Fish	MDS-f, MDS-a II–IV, E-KINDEX, DDS Kennedy, FVS Saibul, DDS Rah, DDS8, DDS Eneman, DDS Torheim, DDS Steyn, The Chinese Children Dietary Index
Milk (and dairy products)	HEI, HEI-2005, MDS, MDS-a I, VIT, YHEI, NZDQI-A, E-KINDEX, DDS Mirmiram, FVS Saibul, DDS Rah, DDS8, DDS Eneman, DDS Torheim, DDS Steyn
High fat dairy	MDS-a II, IV
Oil	MDS-a IV, KIDMED, DDS Kennedy, DDS8, DDS Torheim, DDS Steyn
Potatoes	MDS-a IV, DDS8, DDS Eneman
Cheese	KIDMED
Red wine	MDS-a III
Butter, margarine, animal fat	YHEI, DDS8, DDS Eneman, DDS Steyn
Sweets/sweet beverages	E-KINDEX, KIDMED, DDS Torheim
Dietary variety	DQI-R, DQI-I, HEI, HEI-2005,The Chinese Children Dietary Index
Dietary moderation	DQI-R
Behaviour	
Multivitamin use never	YHEI
Snack foods	YHEI, E-KINDEX
Sweetened beverages	YHEI
Sugary sodas	E-KINDEX
Fried food outside home	YHEI, E-KINDEX, KIDMED
Beverages	The Chinese Children Dietary Index
Breakfast and quality	YHEI, KIDMED, The Chinese Children Dietary Index
Dinner at home	YHEI, The Chinese Children Dietary Index
Physical activity	PDL-Index

Table 4. Overview of items included in means quality index.

9. Uses of quality indices by the food companies

Food industry could uses DQIs to develop healthier menus intended to be consumed by different specific population groups so as to ensure the correct nutritional inputs in terms of macro and micronutrients according to the physiological characteristics of each group. In this way, not to evaluate food products or prepared meals, but within a more global vision such as the field of collective catering (hospitals, nursing homes, schools, colleges and universities). DQIs would be a useful and easy-to-manage tool for assessing the quality of the diet as a whole [101, 102].

10. Conclusions

Indices are a useful tool for epidemiological research, for the development and application of nutritional strategies, for charting changes in eating habits within a given population, and for measuring adherence to dietary guidelines. In the same way, DQIs can be used by the food industry to offer healthier menus within the scope of collective catering. However, it is very difficult to compare findings due to the marked disparity between the variables used in each index. There is clearly a need for an easily-applied index which scores intake of each item on a simple 0/1 basis and adopts a more holistic approach, embracing not only healthy eating habits but also healthy lifestyle choices such as physical activity and a less sedentary way of life.

Author details

Maria Luisa Poyatos Guerrero and Fernando Pérez-Rodríguez*

*Address all correspondence to: b42perof@uco.es

Food Science and Technology Department, University of Córdoba, Córdoba, Spain

References

[1] WHO Library Cataloguing-in-Publication Data, editor. Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013-2020. Switzerland: World Health Organization 2013; 2013. 55 p

[2] WHO Library Cataloguing-in-Publication Data, editor. Global Status Report on Noncommunicable Diseases 2014. Switzerland: World Health Organization 2014; 2014. 298 p

[3] Assman KE, et al. Prospective association of animal protein intake during puberty with body composition in young adulthood. Obesity (Silver Spring). 2013;**21**(12):E782-E789. DOI: 10.1002/oby.20516

[4] Alkerwi A. Diet quality concept. Nutrition. 2014;**30**(6):613-618. DOI: 10.1016/j.nut.2013.10.001

[5] Elmadfa I, Meyer AL. Diet quality, a term subject to change over time. International Journal for Vitamin and Nutrition Research. 2012;**82**(3):144-147. DOI: 10.1024/0300-9831/a000104

[6] Pelletier JE, Laska MN, MacLehose R, Nelson TF, Nanney MS. Evidence-based policies on school nutrition and physical education: Associations with state collaboration, obesity, and socio-economic indicators. Preventive Medicine. 2017;**99**:87-93. DOI: 10.1016/j.ypmed2017.02.005

[7] Patterson RE, Haines PS, Popkin BM. Diet quality index: Capturing a multidimensional behavior. Journal of the American Dietetic Association. 1994;**94**(1):57-64

[8] Gil A, Martinez de Victoria E, Olza J. Indicators for the evaluation of diet quality. Nutrición Hospitalaria. 2015;**31**(Suppl. 3):128-144

[9] Kant AK. Indexes of overall diet quality: A review. Journal of the American Dietetic Association. 1996;**96**(8):785-791. DOI: 10.1016/S0002-8223(96)00217-9

[10] Cusatis DC, Chinchilli VM, Johnson-Rollings N, Kieselhorst K, Stallings VA, Lloyd T. Longitudinal nutrient intake patterns of US adolescent women: The Penn State Young Women's Health Study. Journal of Adolescent Health. 2000;**26**(3):194-204

[11] Martin C, Zhang Y, Tonelli C, Petroni K. Plants, diet, and health. Annual Review of Plant Biology. 2013;**64**:19-46. DOI: 10.1146/annurev-arplant-050312-120142

[12] Pellegrini N, Fogliano V. Cooking, industrial processing and caloric density of foods. Current Opinion in Food Science. 2017;**14**:89-102

[13] Bolzetta F, et al. Are the recommended dietary allowances for vitamins appropriate for elderly people? . Journal of the Academy of Nutrition and Dietetics. 2015;**115**(11):1789-1797. DOI: 10.1016/j.jand.2015.04.013

[14] García A. Nutrient intakes: Concepts and international recommendations (fits part). Nutrición Hospitalaria. 2006;**21**(3):291-299

[15] USDA. Choosemyplate [Internet]. 25/01/2007 [Updated: 25/01/2017]. Available from: https://www.choosemyplate.gov/ten-tips-choose-myplate. [Accessed: 23-03-2017]

[16] García A. Nutrient intakes: Concepts and international recommendations (part two). Nutrición Hospitalaria. 2006;**21**(4):437-447

[17] Aranceta J, Pérez C, Serra-Majem L. Objetivos nutricionales para la población española. Consenso de la Sociedad Española de Nutrición Comunitaria 2011. Revista Española de Nutrición Comunitaria . 2011;**17**(4):178-199. ISSN: 1135-3074

[18] FAO. In: editors. Food Balance Sheets: A Handbook, Rome: Food and Agriculture Organization of the 48 United Nations; 2001

[19] Wilson MA, Reedy J, Krebs-Smith SM. American diet quality: Where it is, where it is heading, and what it could be. Journal of the Academy of Nutrition and Dietetics. 2016;**116**(2):302-310. DOI: 10.1016/j.jand.2015.09.020

[20] Poslusna K, Ruprich J, de Vries JH, Jakubikova M, van't Veer P. Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice. British Journal of Nutrition. 2009;**101**(Suppl 2):S73-S85. DOI: 10.1017/S0007114509990602

[21] Kobayashi S, et al. Both comprehensive and brief self-administered diet history questionnaires satisfactorily rank nutrient intakes in Japanese adults. Journal of Epidemiology. 2012;**22**(2):151-159. DOI: 10.2188/jea.JE20110075

[22] George SM, Ballard R, Shikany JM, Crane TE, Neuhouser ML. A prospective analysis of diet quality and endometrial cancer among 84.415 postmenopausal women in the Women's Helth Initiative. Annals of Epidemiology. 2015;**25**(10):788-793. DOI: 10.1016/j.annepidem.2015.05.009

[23] Freedman MR, Fulgoni VL, 3rd. Canned vegetable and fruit consumption is associated with changes in nutrient intake and higher diet quality in children and adults: National health and nutrition examination survey 2001-2020. Journal of the Academy of Nutrition and Dietetics. 2016;**116**(6):940-948. DOI: 10.1016/j.jand.2015.10.013

[24] Schwingshackl L, Hoffmann G. Diet quality as assessed by the Healthy Eating Index, the Alternate Healthy Eating Index, the Dietary Approaches to Stop Hypertension score, and health outcomes: A systematic review and meta-analysis of cohort studies. Journal of the Academy of Nutrition and Dietetics. 2015;**115**(5):780-800. DOI: 10.1016/j.jand.2014.12.009

[25] Byung-Joon K, et al. Diet quality and diet patterns in relation to circulating cardiometabolic biomarkers. Clinical Nutrition. 2016;**35**(2):484-490. DOI: 10.1016/j.clnu.2015.03.022

[26] Bail J, Meneses K, Demark-Wahnefried W. Nutritional status and diet in cancer prevention. Seminars in Oncology Nursing. 2016;**32**(3):206-214. DOI: 10.1016/j.soncn.2016.05.004

[27] Nissensohn M, Román-Viñas B, Sánchez-Villegas A, Piscopo S, Serra-Majem L. The effect of the mediterranean diet on hypertension: A sistematic review and meta-analysis. Journal of Nutrition Education and Behavior. 2016;**48**(1):42-53. DOI: 10.1016/j.jneb.2015.08.023

[28] Kant AK. Dietary patterns and health outcomes. Journal of the American Dietetic Association. 2004;**104**(4):615-635. DOI: 10.1016/j.jada.2004.01.010

[29] Waijers PM, Feskens EJ, Ocké MC. A critical review of predefined diet quality scores. British Journal of Nutrition. 2007;**97**(2):219-231. DOI: 10.1017/S0007114507250421

[30] Arvaniti F, Panagiotakos DB. Healthy indexes in public health practice and research: A review. Critical Reviews in Food Science and Nutrition. 2008;**48**(4):317-327. DOI: 10.1080/10408390701326268

[31] Bach A, et al. The use of indexes evaluating the adherence to the Mediterranean diet in epidemiological studies: A review. Public Health Nutrition. 2006;**9**(1a):132-146. DOI: 10.1079/PHN2005936

[32] Lazarou C, Newby PK. Use of dietary indexes among children in developed countries. Advances in Nutrition. 2011;**2**(4):295-303. DOI: 10.3945/an.110.000166

[33] Marshall S, Burrows T, Collins CE. Systematic review of diet quality indices and their associations with health-related outcomes in children and adolescents. Journal of Human Nutrition and Dietetics. 2014;**27**(6):577-598. DOI: 10.1111/jhn.12208

[34] Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index revised: A measurement instrument for populations. Journal of the American Dietetic Association. 1999;**99**(6):697-704. DOI: 10.1016/S0002-8223(99)00168-6

[35] Fung TT, et al. Diet-quality scores and plasma concentrations of markers of inflammation and endothelial dysfunction. American Journal of Clinical Nutrition. 2005;**82**(1):163-173

[36] Kennedy ET, Ohls J, Carlson S, Fleming K. The Healthy Eating Index: Design and applications. Journal of the American Dietetic Association. 1995;**95**(10):1103-1108. DOI: 10.1016/S0002-8223(95)00300-2

[37] Britten P, Marcoe K, Yamini S, Davis C. Development of food intake patterns for the MyPyramid Food Guidance System. Journal of Nutrition Education and Behavior. 2006;**38**(6 Suppl):S78-S92. DOI: 10.1016/j.jneb.2006.08.007

[38] Guenther PM, Reedy J, Krebs-Smith SM. Development of the Healthy Eating Index-2005. Journal of the American Dietetic Association. 2008;**108**(11):1896-1901. DOI: 10.1016/j.jada.2008.08.016

[39] Guenther P, et al. Update of the Healthy Eating Index: HEI-2010. Journal of the Academy of Nutrition and Dietetics. 2013;**116**(4):170-175. DOI: 10.1016/j.jand.2012.12.016

[40] Cox DR, Skinner JD, Carruth BR, Moran J, Houck KS. A Food Variety Index for Toddlers (VIT): Development and application. Journal of the American Dietetic Association. 1997;**97**(12):1382-1386; quiz 1387-8

[41] Feskanich D, Rockett HR, Colditz GA. Modifying the Healthy Eating Index to assess diet quality in children and adolescents. Journal of the American Dietetic Association. 2004;**104**(9):1375-1383. DOI: 10.1016/j.jada.2004.06.020

[42] Huijbregts P, et al. Dietary pattern and 20 year mortality in elderly men in Finland, Italy, and The Netherlands: Longitudinal cohort study. BMJ. 1997;**315**(7099):13-17

[43] Kim S, Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index-International (DQI-I) provides an effective tool for cross-national comparison of diet quality as illustrated by China and the United States. The Journal of Nutrition. 2003;**133**(11):3476-3484

[44] Tur JA, Romaguera D, Pons A. The Diet Quality Index-International (DQI-I): Is it a useful tool to evaluate the quality of the Mediterranean diet? British Journal of Nutrition. 2005;**93**(3):369-376

[45] Keys A, editor. Seven Countries. A Multivariate Analysis of Death and Coronary Heart Disease. 1st ed. Cambridge: Harvard University Press; 1980. 381 p

[46] Keys A, et al. The diet and 15-year death rate in the seven countries study. American Journal of Epidemiology. 1986;**124**(6):903-915

[47] Trichopoulou A, Vasilopoulou E. Mediterranean diet. Encyclopedia of Food and Health. 2016;711-714. DOI: 10.1016/B978-0-12-384947-2.00454-2

[48] Kastorini CM, et al. Metabolic syndrome, adherence to the Mediterranean diet and 10-year cardiovascular disease incidence: The ATTICA study. Atherosclerosis. 2016;**246**:87-93

[49] Arós F., Estruch R. Dieta mediterránea y prevención de la enfermedad cardiovasular. Rev Esp Cardiol. 2013; **66**(10): 771-4. DOI: 10.1016/j.recesp.2013.04.026

[50] Guallar-Castillón P, et al. Major dietary patterns and risk of cohoronary heart disease in middle-aged persons from a Mediterranean country: The EPIC- Spain country study. Nutrition, Metabolism, and Cardiovascular Diseases. 2012;**22**(3):192-199. DOI: 10.1016/j.numecd.2010.06.004

[51] Cueto-Galán R, et al. Changes in fatty liver index after consuming a Mediterranean diet: 6-year follow-up of the PREDIMED- Malaga trial. Medicina Clínica. 2017;**148**(10):435-443. DOI: 10.1016/j.medcli.2016.11.032

[52] Ruiz-Cabello P, et al. Influence of the degree of adherence to the Mediterranean diet on the cardiometabolic risk in peri and menopausal women. The Flamenco project. Nutrition, Metabolism, and Cardiovascular Diseases. 2017;**27**(3):217-224. DOI: 10.1016/j.numecd.2016.10.008

[53] Della Corte C, et al. Good adherence to the Mediterranean diet reduces the risk for NASH and diabetes in pediatric patients with obesity: The results of an Italian Study. Nutrition. 2017;**39-40**:8-14

[54] Izadi V, et al. Adherence to the DASH and Mediterranean diets is associated with decreased risk for gestational diabetes mellitus. Nutrition. 2016;**32**(10):1092-1096. DOI: 10.1016/j.nut.2016.03.006

[55] Trichopoulou A, et al. Diet and overall survival in elderly people. BMJ. 1995;**311**(7018): 1457-1460

[56] Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. New England Journal of Medicine 2003;**348**:2599-2608. DOI: 10.1056/NEJMoa025039

[57] Schröder H, et al. A short screener is valid for assessing Mediterranean diet adherence among older Spanish men and women. The Journal of Nutrition. 2011;**141**(6):1140-1145. DOI: 10.3945/jn.110.135566

[58] Martínez-González M, et al. Benefits of the mediterranean diet: Insights from the PREDIMED study. Progress in Cardiovascular Diseases. 2015;**58**(1):50-60. DOI: 10.1016/j.pcad.2015.04.003

[59] Serra-Majem L, et al. Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. Public Health Nutrition. 2004;**7**(7):931-935

[60] Toktas N, Yildiz Y. Assessment of nutritional status of 10-14 years old adolescents using Mediterranean Diet Quality Index (kidmed). Procedia-Social and Behavioral Sciences. 2013;**106**:512-518. DOI: 10.1016/j.sbspro.2013.12.057

[61] Mistretta A, et al. Mediterranean diet adherence and body composition among Southern Italian adolescents. Obesity Research & Clinical Practice. 2017;**11** (2):215-226. DOI: 10.1016/J.ORCP.2016.05.007

[62] Idelson P, Scalfi L, Valerio G. Adherence to the Mediterranean diet in children and adolescents: A systematic review. Nutrition, Metabolism, and Cardiovascular Diseases. 2017;**27**(4):283-299. DOI: 10.1016/j.numecd.2017.01.002

[63] Bonaccio M, Bes-Rastrollo M, de Gaetano G, Iacoviello L. Challenges to the Mediterranean diet at a time of economic crisis. Nutrition, Metabolism, and Cardiovascular Diseases. 2016;**26**(12):1057-1063. DOI: 10.1016/j.numecd.2016.07.005

[64] Rizza W, De Gara L, Incalzi RA, Pedone C. Prototypical versus contemporary Mediterranean Diet. Clinical Nutrition ESPEN. 2016;**15**:44-48. DOI: 10.1016.j.clnesp.2016.06.007

[65] Sotos-Prieto M, Moreno-Franco B, Ordovás JM, León M, Casasnovas JA, Peñalvo JL. Design and development of an instrument to measure overall lifestyle habits for epidemiological research: the Mediterranean Lifestyle (MEDLIFE) index. Public Health Nutrition. 2015;**18**(6):959-967. DOI: 10.1017/S1368980014001360

[66] Lazarou C, Panagiotakos DB, Spanoudis G, Matalas AL. E-KINDEX: A dietary screening tool to assess children's obesogenic dietary habits. Journal of the American College of Nutrition. 2011;**30**(2):100-112

[67] Lazarou C, Karaolis M, Matalas A, Panagiotakos DB. Dietary patterns analysis using data mining method. An application to data from the CYKIDS study. Computer Methods and Programs in Biomedicine. 2012;**108**(2):706-714. DOI: 10.1016/j.cmpb.2011.12.011

[68] Manios Y, Kourlaba G, Grammatikaki E, Androutsos O, Moschonis G, Roma-Giannikou E. Development of a diet–lifestyle quality index for young children and its relation to obesity: The Preschoolers Diet–Lifestyle Index. Public Health Nutrition. 2010;**13**(12):2000-2009. DOI: 10.1017/s1368980010000698

[69] Manios Y, Moschonis G, Grammatikaki E, Anastasiadou A, Liarigkovinos T. Determinants of childhood obesity and association with maternal perceptions of their children’s weight status: The “GENESIS” study. Journal of the American Dietetic Association. 2010;**110**(10):1527-1531. DOI: 10.1016/j.jada.2010.07.004

[70] Marshall S, Burrows T, Collins CE. Systematic review of diet quality indices and their associations with health-related outcomes in children and adolescents. Journal of Human Nutrition and Dietetics. 2014;**27**(6):557-598. DOI: 10.1111/jhn.12208

[71] Ramsay S, Shriver L, Taylor C. Variety of fruit and vegetables is related to preschoolers’ overall diet quality. Preventive Medicine Reports. 2017;**5**:112-117. DOI: 10.1016/j.pmedr.2016.12.003

[72] Spence A, McNaughton S, Lioret S, Hesketh K, Crawford D, Campbell K. A health promotion intervention can affect diet quality in early childhood. The Journal of Nutrition. 2013;**143**(10):1672-1678. DOI: 10.3945/jn.113.177931

[73] Scott JA, Chih TY, Oddy WH. Food variety at 2 years of age is related to duration of breastfeeding. Nutrients. 2012;**4**(10):1464-1474. DOI: 10.3390/nu4101464

[74] Marshall S, Watson J, Burrows T, Guest M, Collins CE. The development and evaluation of the Australian child and adolescent recommended food score: A cross-sectional study. Nutrition Journal 2012;**11**:96. DOI: 10.1186/1475-2891-11-96

[75] Collins L, Lacy K, Campbell K, McNaughton S. The predictors of diet quality among Australian children aged 3.5 years. Journal of the Academy of Nutrition and Dietetics. 2016;**116**(7):1114-1126. DOI: 10.1016/j.jand.2015.12.014

[76] Kleiser C, Mensink GB, Scheidt-Nave C, Kurth BM. HuSKY: A healthy nutrition score based on food intake of children and adolescents in Germany. British Journal of Nutrition. 2009;**102**(4):610-618. DOI: 10.1017/s0007114509222689

[77] Alexy U, Sichert-Hellert W, Kersting M, Lausen B, Schöch G. Development of scores to measure the effects of nutrition counselling on the overall diet: A pilot study in children and adolescents. European Journal of Nutrition. 1999;**38**(4):196-200

[78] Kohlboeck G, et al. Food intake, diet quality and behavioral problems in children: Results from the GINI-plus/LISA-plus Studies. Annals of Nutrition and Metabolism. 2012;**60**:247-256. DOI: 10.1159/000337552

[79] Kyttälä P, et al. Finnish Children Healthy Eating Index (FCHEI) and its associations with family and child characteristics in pre-school children. Public Health Nutrition. 2014;**17**(11):2519-2527. DOI: 10.1017/S1368980013002772

[80] Maiz E., Balluerka N. Nutritional status and Mediterranean diet quality among Spanish children and adolescents with food neophobia. Food Quality and Preference. 2016;**52**:113-142. DOI: 10.1016/j.foodqual.2016.04.011

[81] Royo-Bordonada MA. Greater dietary variety is associated with better biochemical nutritional status in Spanish children: The Four Provinces Study. NMCD. 2003;**13**(6):357-364. DOI: 10.1016/S0939-4753(03)80004-2

[82] Pérez-Fainós N, et al. The ALADINO study: A national study of prevalence of overweight and obesity in Spanish children in 2011. BioMed Research International. 2013;**2013**:163687. DOI: 10.1155/2013/163687

[83] Fung C, McIsaac J, Kuhle S, Kirk S, Veugelers P. The impact of a population-level school food and nutrition policy on dietary intake and body weights of Canadian children. Preventive Medicine. 2013;**57**(6):934-940. DOI: 10.1016/j.ypmed.2013.07.016

[84] Chu Y, Storey K, Veugelers P. Involvement in meal preparation at home is associated with better diet quality among Canadian children. Journal of Nutrition Education and Behavior. 2014;46(4):304-308

[85] Cheng G, Duan R, Kranz S, Libuda L, Zhang L. Development of a dietary index to assess overall diet quality for Chinese school-aged children: The Chinese children dietary index. Journal of the Academy of Nutrition and Dietetics. 2016;**116** (4):608-617. DOI: 10.1016/J.JAND.2015.11.010

[86] Kennedy GL, Pedro MR, Seghieri C, Nantel G, Brouwer I. Dietary diversity score is a useful indicator of micronutrient intake in non-breast-feeding Filipino children. The Journal of Nutrition. 2007;**137**(2):472-477

[87] Falciglia GA, Troyer AG, Couch SC. Dietary variety increases as a function of time and influences diet quality in children. Journal of Nutrition Education and Behavior. 2004;**36**(2):77-83

[88] Arimond M, Ruel MT. Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. The Journal of Nutrition. 2004;**134**(10):2579-2585

[89] Hoddinott J, Yohannes Y. In: Academy for Educational Development, editor. Dietary Diversity as a Food. Food Consumption and Nutrition Division Discussion Paper 136, Washington: Food and Nutrition Technical Assistance Project (FANTA); 2002. pp. 1-54

[90] Onyango A, Koski KG, Tucker KL. Food diversity versus breastfeeding choice in determining anthropometric status in rural Kenyan toddlers. International Journal of Epidemiology. 1998;**27**(3):484-489

[91] Saibul N, Shariff ZM, Lin KG, Kandiah M, Ghani NA, Rahman H. Food variety score is associated with dual burden of malnutrition in Orang Asli (Malaysian indigenous peoples) households: Implications for health promotion. Asia Pacific Journal of Clinical Nutrition. 2009;**18**:412-422

[92] Roche ML, Creed-Kanashiro HM, Tuesta I, Kuhnlein HV. Traditional food diversity predicts dietary quality for the Awajún in the Peruvian Amazon. Public Health Nutrition. 2008;**11**(5):457-465. DOI: 10.1017/S1368980007000560

[93] Enneman A, Hernández L, Campos R, Vossenaar M, Solomons NW. Dietary characteristics of complementary foods offered to Guatemalan infants vary between urban and rural settings. Nutrition Research. 2009;**29**(7):470-479. DOI: 10.1016/j.nutres.2009.06.007

[94] Eckhardt CL, Suchindran C, Gordon-Larsen P, Adair LS. The association between diet and height in the postinfancy period changes with age and socioeconomic status in Filipino youths. The Journal of Nutrition. 2005;**135**(9):2192-2198

[95] Rah JH, et al. Low dietary diversity is a predictor of child stunting in rural Bangladesh. European Journal of Clinical Nutrition. 2010;**64**(12):1393-1398. DOI: 10.1038/ejcn.2010.171

[96] Wong JE, Parnell WR, Black KE, Skidmore PM. Reliability and relative validity of a food frequency questionnaire to assess food group intakes in New Zealand adolescents. Nutrition Journal. 2012;**11**:65. DOI: 10.1186/1475-2891-11-65

[97] Wong J, Parnell W, Howe A, Black K, Skidmore P. Development and validation of a food-based diet quality index for New Zealand adolescents. BMC Public Health. 2013;**13**:562. DOI: 10.1186/1471-2458-13-562

[98] WHO Multicentre Growth Reference Study Group. Complementary feeding in the WHO Multicentre Growth Reference Study. Acta Paediatrics. 2006;**450**(Suppl):27-37

[99] Moursi MM, Arimond M, Dewey KG, Trèche S, Ruel MT, Delpeuch F. Dietary diversity is a good predictor of the micronutrient density of the diet of 6- to 23-month-old children in Madagascar. The Journal of Nutrition. 2008;**138**(12):2448-2453. DOI: 10.3945/jn.108.093971

[100] IRD/GRET/LABASAN. Nutrimad: Programme de lutte contre la malnutrition a` Madagascar, une composante du programme Nutridev GRET/IRD [Internet]. Available from: http://www.rencontres-montblanc.coop/node/1151 [Accessed: 22-03-2017]

[101] De Mateo B, et al. Diseño y aplicación de un cuestionario de calidad dietética de los menús escolares. Nutrición Hospitalaria. 2015;**31**(1):225-235

[102] Morán L, et al. La planificación del menú escolar; resultado de un sistema de asesoría dietética para la adecuación a las recomendaciones nutricionales. Nutrición Hospitalaria. 2013;**28**(4):1145-1150