# Diet Quality: Setting the Scene

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**Key Points**

- Diet quality is a subjective term that is often used within the context of a deficiency or excess of nutrients or foods.
- Attempts have been made to translate such subjectivity into objective measures, namely via scoring systems. Such scoring systems comprise nutrients and foods or food groups that are assumed to be either healthy or detrimental.
- This chapter briefly describes a few scoring systems, namely the Healthy Eating Index (HEI), Diet Quality Index (DQI), Diet Quality Index-International (DQI-I), Healthy Diet Indicator (HDI), and the Mediterranean Diet Score (MDS).
- These selective examples illustrate the nature of the scoring systems, their attributes, and applications.
- Some of these scoring systems correlate with biomarkers, mortality, cognitive impairment, and other variables.
- On the other hand some studies are negative, suggesting that the scoring systems may not be applicable to all situations.

**Keywords**

Diet quality • Health Eating Index (HEI) • Diet Quality Index (DQI) • Healthy Diet Indicator (HDI) • Mediterranean Diet Score (MDS) • Diet Quality Index-International (DQI-I)

## Abbreviations

| | |
|---|---|
| AHEI | Alternative Healthy Eating Index |
| AI | Adequate Intake |
| ATP | Adenosine triphosphate |
| CHO | Carbohydrate |
| CVD | Cardiovascular disease |
| DGI | Dietary Guidelines Index |
| DQI | Diet Quality Index |

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| | |
|---|---|
| DQI-I | Diet Quality Index-International |
| DQI-R | Diet Quality Index Revised |
| FBQI | Food-Based Quality Index |
| FPI | Food Pyramid Index |
| Hb | Hemoglobin |
| HDI | Healthy Diet Indicator |
| HDL | High density lipoprotein |
| HEI | Healthy Eating Index |
| HFI | Healthy Food Index |
| MAR | Mean Adequacy Ratio |
| MDQI | Mediterranean Diet Quality Index |
| MDS | Mediterranean Diet Score |
| MUFA | Monounsaturated fatty acid |
| NAR | Nutrient Adequacy Ratio |
| PRO | Protein |
| PUFA | Polyunsaturated fatty acid |
| RDA | Recommended Dietary Allowance |
| RNI | Recommended Nutrient Intake |
| SFA | Saturated fatty acid |

## Introduction

The human diet is composed of many different nutrients, which contribute to maintaining normal bodily functions. Components of the diet may be used to provide metabolic fuels (e.g., the breakdown of macronutrients to form adenosine triphosphate (ATP) which may be used to maintain the sodium potassium balance across cells), building blocks (e.g., amino acids for cytoskeletal proteins), or components of various cellular constituents (e.g., selenium as part of glutathione peroxidase).

In nutritional epidemiology, the focus has mainly been directed towards the role of such single dietary components [1]. This "reductionist" approach can reveal the relationship of individual nutrients or foods in disease development [1, 2]. However, this approach disregards the true complexity of the human diet, and therefore the true relationship between diet and disease [3]. This is because the food matrix is a composite mixture of individual components, many of which do not appear in the established lists of dietary reference values or recommended daily intakes. Additionally, within the body, there are many nutrient-to-nutrient interactions that further complicate the associations between single dietary components and disease [4]. For this matter, a "holistic" approach is usually undertaken to evaluate diet quality based on patterns of intake [3].

**Table 1.1** Characteristics of predefined indices of overall diet quality

| |
|---|
| Created beforehand ("a priori") |
| Researcher selects attributes: nutrients, foods or food groups, and/or an indicator of dietary variety |
| Built upon current nutrition knowledge |
| Often represents nutrition guidelines or recommendations |
| Or based on diet that has proven healthful (e.g., Mediterranean diet) |

*Source*: Waijers and Feskens [3]

Dietary patterning can be defined as theoretically defined dietary patterns or empirically derived dietary patterns [1]. The latter is examined in "a posteriori" approach, where statistical methods such as factor and cluster analyses are used to generate patterns from collected food consumption data [1, 3, 5]. Theoretically defined dietary patterns (dietary indices/scores), on the other hand, are created "a priori." They are made up of nutritional variables (foods and/or nutrients) and based on current nutrition knowledge [1, 3, 5]. These variables are quantified and summed to provide an overall measure of diet quality [1, 5]. The ensuing material will focus on predefined indices of overall diet quality. Unfortunately, the term *diet quality* has been defined and used in different ways. However, there have been various attempts to make the concept of diet quality more objective, quantitative, and measurable. Table 1.1 provides a basic breakdown of the attributes and key issues in the construction of predefined indices of diet quality [3].

A variety of diet indices or tools have been developed to assess overall diet quality [6]. Typically, these indices are constructed on the basis of dietary recommendations, such as "servings" of food items in the US Department of Agriculture Food Guide Pyramid [4, 7].

## Existing Indices of Diet Quality

There are several systems of scoring that have been validated by relating the index to health outcome. Table 1.2 provides an overview of existing diet quality indices and studies in

**Table 1.2** Overview of existing diet quality measures and studies in which they have been used and/or evaluated

| Index | Authors |
|---|---|
| *Based on dietary guidelines* | |
| **Diet Quality Index (DQI)**[a] | **Patterson et al.** [9]<br>Seymour et al. [13]<br>Dubois et al. [14] |
| Diet Quality Index Revised (DQI-R) | **Haines et al.** [15]<br>Newby et al. [16]<br>Fung et al. [17] |
| Diet Quality Index International (DQI-I) | **Kim et al.** [12] |
| Other indices adapted from the DQI | |
| DQI-a I | Drewnowski et al. [18] |
| DQI-a II | Drewnowski et al. [19] |
| DQI-a III | Lowik et al. [20] |
| **Healthy Eating Index (HEI)**[a] | **Kennedy et al.** [8]<br>McCullough et al. [21]<br>McCullough et al. [22]<br>Dubois et al. [14]<br>Kennedy et al. [23]<br>Hann et al. [24]<br>McCullough et al. [25]<br>Weinstein et al. [26]<br>Fung et al. [17] |
| Alternative Healthy Eating Index (AHEI) | **McCullough et al.** [25]<br>Fung et al. [17] |
| **Healthy Diet Indicator (HDI)**[b] | **Huijbregts et al.** [10, 27]<br>Huijbregts et al. [28]<br>Dubois et al. [14]<br>Haveman-Nies et al. [29] |
| **Dietary Guidelines Index (DGI)** | **Harnack et al.** [30] |
| *Based on Mediterranean diet* | |
| **Mediterranean Diet Score (MDS)** | **Trichopoulou et al.** [11]<br>Osler and Schroll [31]<br>Kouris-Blazos et al. [32]<br>Lasheras et al. [33]<br>Woo et al. [34]<br>Haveman-Nies et al. [29]<br>Bosetti et al. [35] |
| Mediterranean Diet Quality Index (MDQI) | **Gerber et al.** [36]<br>Scali et al. [37] |
| MDS + fish (MDS-f) | **Trichopoulou et al.** [38]<br>Knoops et al. [39]<br>Trichopoulou et al. [40] |
| Other indices adapted from the MDS | |
| MDS-a I | **Haveman-Nies et al.** [41] |
| MDS-a II | Schroder et al. [42] |
| MDS-a III | Fung et al. [17] |
| MDS-a IV | Pitsavos et al. [43] |
| *Food-based* | |
| Food-Based Quality Index (FBQI) | **Lowik et al.** [20] |
| Healthy Food Index (HFI) | **Osler et al.** [44]<br>Osler et al. [45] |
| Food Pyramid Index (FPI) | **Massari et al.** [46] |
| *Nutrient-based* | |
| **Nutrient Adequacy Ratio (NAR/MAR)**[c] | **Madden and Yoder** [47] |

*Source*: Waijers et al. [1]
Publications in which the index was first published are shown in bold
[a]Based on US dietary recommendations
[b]Based on 1990 WHO dietary guidelines
[c]Nutrient Adequacy Ratio (NAR) is the ratio of intake of a nutrient relative to its Recommended Dietary Allowance (RDA). The Mean Adequacy Ratio (MAR) is computed by averaging the sum of the NAR. These scores have been used in several studies, and also to evaluate diet quality scores

which they have been used and/or evaluated [3]. Some of the most common of these indices are the Healthy Eating Index (HEI) [8], Diet Quality Index (DQI) [9], Healthy Diet Indicator (HDI) [10], and the Mediterranean Diet Score (MDS) [11]. The Diet Quality Index-International (DQI-I) [12], which is a derivative of the DQI, is a fairly recent predefined measure created for global monitoring and exploring diet quality across countries. Prior to the development of this index, cross-national comparison of diet quality had rarely been attempted [12].

There are some indices, such as the Food-Based Quality Index (FBQI), that consist solely of foods or food groups. Other indices like the adapted DQIs consist of just nutrients. The majority of indices, however, comprise both food groups and nutrients [3]. Table 1.3 includes an overview of the attributes found in the scoring systems mentioned below [8–47].

## Healthy Eating Index

The HEI is a 10-component, 100-point measure of diet quality that assesses conformance to US dietary guidelines [48]. It is based on five different food groups (grains, vegetables, fruits, milk, and meat), four nutrients (total fat, saturated fatty acids (SFAs), cholesterol, and sodium), and a measure of the variety in food intake [8].

A HEI score of 80 or more indicates a good diet; scores between 50 and 80 suggest that a diet needs improvements, and scores less than 50 consider a diet to be poor [49]. Table 1.4 shows an overview of the HEI.

Hann et al. [24] and Weinstein et al. [26] found that the HEI was associated with a wide range of nutritional biomarkers of micronutrients, i.e., alpha-carotene, beta-carotene, beta-cryptoxanthin, and vitamin C. They explain that consumption of these nutrients is a common indicator of fruits and vegetables, and therefore consumption of these food groups [24]. Both studies found no significant correlation between HEI score and cholesterol [24, 26]. A study by Dubois et al. [14] analyzed three different methods to measuring overall diet quality. They found that the HEI had a higher correlation with the Mean Adequacy Ratio (MAR = 0.287) of several nutrients, compared to the DQI and HDI.

Data on the relationship between the HEI score and mortality is lacking. However, there are four studies that have examined the relationship between HEI and disease risk [21, 22, 25, 30]. Harnack et al. [30] found no significant association between the HEI score with cancer incidence [30]. In the McCullough et al. [21, 22] studies, a weak inverse association between HEI score and chronic disease risk (cardiovascular disease (CVD) and cancer) was reported [21]. They did not report such an association with overall chronic disease risk in women, and only a weak inverse association with CVD risk [22].

The HEI is based on US dietary guidelines and, to a certain extent, measures how individuals follow these guidelines. However, further work is needed to firmly establish the HEI as a good predictor of health outcome. Nevertheless, the HEI shows correlations with plasma biomarkers such as alpha-carotene, beta-carotene, beta-cryptoxanthin, and vitamin C [24].

**Table 1.3** Overview of attributes included in theoretically defined indices of diet quality

| |
|---|
| Nutrients |
| Fat-related variables: total fat, saturated fat, cholesterol, MUFA/SFA |
| Carbohydrates: (complex) carbohydrates, mono- and disaccharides, sucrose |
| Dietary fiber |
| Protein |
| Micronutrients: sodium, calcium, iron, vitamin C |
| Alcohol |
| Foods of food groups |
| Vegetables and fruit: vegetables, vegetables and fruit, fruit, fruit and nuts, legumes, legumes and nuts, etc. |
| Meats (and meat products) |
| Cereals or grains |
| Milk (and dairy) |
| Others: fish, olive oil, cheese |
| Dietary diversity or dietary variety |
| Dietary moderation |

*Source*: Waijers and Feskens [3]
*MUFA* monounsaturated fatty acid, *SFA* saturated fatty acid

**Table 1.4** Health Eating Index (HEI)

| | Scoring | | |
|---|---|---|---|
| Component | Criteria for score 0 | Criteria for score 10[a] | Range |
| Grains | 0 servings | 6–11 servings | 0–10 |
| Vegetables | 0 servings | 3–5 servings | 0–10 |
| Fruits | 0 servings | 2–4 servings | 0–10 |
| Milk | 0 servings | 2–3 servings | 0–10 |
| Meat | 0 servings | 2–3 servings | 0–10 |
| Total fat | >45 energy % | <30 energy % | 0–10 |
| Saturated fatty acids | >15 energy % | <10 energy % | 0–10 |
| Cholesterol | >450 mg | <300 mg | 0–10 |
| Sodium | >4,800 mg | <2,400 mg | 0–10 |
| Variety | ≤6 different food items/3 days | 16 different food items/3 days | 0–10 |

*Source*: Kennedy et al. [8]
[a]Depending on energy intake

## Healthy Diet Indicator

The HDI (Table 1.5) was developed in the Netherlands [3] and is based on the World Health Organisation's dietary recommendations for the prevention of chronic disease [50]. The HDI is made up of nine micro- and macronutrient components [3, 10]. It uses a 9-point measure of four nutrients (SFAs, polyunsaturated fatty acids (PUFAs), mono- and disaccharides, and cholesterol) and five food groups (complex carbohydrates, dietary fiber, fruits and vegetables, and pulses, nuts, and seeds). Typically, the higher the overall HDI score, the better the diet quality.

Huijbregts et al. [10, 27] reported the HDI to be inversely associated with all-cause mortality in men [10] but not women [27]. Huijbregts et al. [28] also suggested a healthy HDI score to correlate with better cognitive function in elderly men. Dubois et al. [14] reported that the HDI score only slightly correlated with MAR (0.079). Moreover, Haveman-Nies et al. [29] found no association between HDI score and albumin, hemoglobin (Hb), or waist circumference.

## Diet Quality Index and Diet Quality Index-International and Health Outcome

The DQI is made up of eight components (Table 1.6) and is based on the US recommendations from *Diet and Health* [51]. The DQI uses a 16-point measure, where a high score is indicative of a poor diet quality (unlike the previously mentioned dietary indices).

Dubois et al. [14] showed the DQI to only marginally correlate with nutrient adequacy. One study by Seymour et al. [13] found that a high DQI score was positively associated with all-cause mortality. Moreover, persons with a high DQI score had lower CVD-mortality, but no association was found between cancer mortality and the DQI score [13].

The DQI-I is an adapted version of the DQI [12]. It is divided into four major components, including, variety, adequacy, moderation, and empty calorie foods (Table 1.7). The total DQI-I score ranges from 0 to 100, where a score of "0" reflects an extremely poor diet, and a score of "100" (highest possible score) indicates a high quality diet [12]. The differences between the original DQI and the DQI-I indices are significant. The DQI-I not only is more extensive than

**Table 1.5** Healthy Diet Indicator (HDI)

| Nutrient or food group | Scoring | |
|---|---|---|
| SFA | 0–10 energy % | 1 (else: 0) |
| PUFA | 3–7 energy % | 1 (else: 0) |
| Protein | 10–15 % energy | 1 (else: 0) |
| Complex carbohydrates | 50–70 energy % | 1 (else: 0) |
| Dietary fiber | 27–40 g/day | 1 (else: 0) |
| Fruits and vegetables | >400 g/day | 1 (else: 0) |
| Pulses, nuts, and seeds | >30 g/day | 1 (else: 0) |
| Mono- and disaccharides | 0–10 energy % | 1 (else: 0) |
| Cholesterol | 0–300 mg/day | 1 (else: 0) |

*Source*: Huijbregts et al. [10]
*SFA* saturated fatty acid, *PUFA* polyunsaturated fatty acid

**Table 1.6** Diet Quality Index (DQI[a])

| Component | Scoring | |
|---|---|---|
| Total fat | <30 energy % | 0 |
| | 30–40 energy % | 1 |
| | >40 energy % | 2 |
| Saturated fatty acids | <10 energy % | 0 |
| | 10–13 energy % | 1 |
| | >13 energy % | 2 |
| Cholesterol | <300 mg | 0 |
| | 300–400 mg | 1 |
| | >400 mg | 2 |
| Fruits and vegetables | 5+ servings | 0 |
| | 3–4 servings | 1 |
| | 0–2 servings | 2 |
| Complex carbohydrates | 6+ servings | 0 |
| | 4–5 servings | 1 |
| | 0–3 servings | 2 |
| Protein | ≤100 % RDA | 0 |
| | 100–150 % RDA | 1 |
| | >150 % RDA | 2 |
| Sodium | <2,400 mg | 0 |
| | 2,400–3,400 mg | 1 |
| | >3,400 mg | 2 |
| Calcium | ≥RDA | 0 |
| | 2/3 RDA | 1 |
| | <2/3 RDA | 2 |

*Source*: Patterson et al. [9]
*RDA* Recommended Dietary Allowance
[a]Based on US recommendations from Diet and Health (National Research Council, Committee on Diet and Health) [50]

**Table 1.7** Diet Quality Index-International (DQI-I)

| Component | Score (points) | Scoring criteria |
|---|---|---|
| *Variety* | 0–20 | |
| Overall food group variety (meat/poultry/fish/eggs, dairy/beans, grain, fruit, vegetable) | 0–15 | ≥1 serving from each food group/day = 15<br>Any 1 food group missing/day = 12<br>Any 2 food groups missing/day = 9<br>Any 3 food groups missing/day = 6<br>≥4 food groups missing/day = 3<br>None from any food groups = 0 |
| Within-group variety for protein source (meat, poultry, fish, diary, beans, eggs) | 0–5 | ≥3 different sources/day = 5<br>2 different sources/day = 3<br>From 1 source/day = 1<br>None = 0 |
| *Adequacy* | 0–40 | |
| Vegetable group | 0–5 | ≥3–5 servings/day = 5, 0 servings/day = 0 |
| Fruit group | 0–5 | ≥2–4 servings/day = 5, 0 servings/day = 0 |
| Grain group | 0–5 | ≥6–11 servings/day = 5, 0 servings/day = 0 |
| Fiber | 0–5 | ≥20–30 g/day = 5, 0 g/day = 0 |
| Protein | 0–5 | ≥10 % of energy/day = 5, 0 % of energy/day = 0 |
| Iron | 0–5 | ≥100 % RDA (AI)/day = 5, 0 % RDA (AI)/day = 0 |
| Calcium | 0–5 | ≥100 % (AI)/day = 5, 0 % (AI)/day = 0 |
| Vitamin C | 0–5 | ≥100 % RDA (RNI)/day = 5, 0 % RDA (RNI)/day = 0 |
| *Moderation* | 0–30 | |
| Total fat | 0–6 | ≤20 % of total energy/day = 6<br>>20–30 % of total energy/day = 3<br>>30 % of total energy/day = 0 |
| Saturated fat | 0–6 | ≤7 % of total energy/day = 6<br>>7–10 % of total energy/day = 3<br>>10 % of total energy/day = 0 |
| Cholesterol | 0–6 | ≤300 mg/day = 6<br>>300–400 mg/day = 3<br>>400 mg/day = 0 |
| Sodium | 0–6 | ≤2,400 mg/day = 6<br>>2,400–3,400 mg/day = 3<br>>3,400 mg/day = 0 |
| Empty calorie foods | 0–6 | ≤3 % of total energy/day = 6<br>>3–10 % of total energy/day = 3<br>>10 % of total energy/day = 0 |
| *Overall balance* | 0–10 | |
| Macronutrient ratio (CHO:PRO:FAT) | 0–6 | 55–65:10–15:15–25 = 6<br>52–68:9–16:13–27 = 4<br>50–70:8–17:12–30 = 2<br>Otherwise = 0 |
| Fatty acid ratio (PUFA:MUFA:SFA) | 0–4 | P/S = 1–1.5 and M/S = 1–1.5 = 4<br>Else if P/S = 0.8–1.7 and M/S = 0.8–1.7 = 2<br>Otherwise = 0 |

*Source*: Kim et al. [12]
*RDA* Recommended Dietary Allowance, *AI* Adequate Intake, *RNI* Recommended Nutrient Intake, *CHO* carbohydrate, *PRO* protein, *PUFA* polyunsaturated fatty acid, *MUFA* monounsaturated fatty acid, *SFA* saturated fatty acid

the DQI but also has attributed different weights to the individual components [3]. Thus, the DQI-I incorporates both nutrient and food perspectives of the assessed diet, providing a more grounded tool to describe the diversity of consumption observed from country to country [12]. Kim et al. [12] have suggested that the DQI-I can indentify dietary problem areas. Like the DQI, a high score on the DQI-I, suggests a good diet quality.

## Mediterranean Diet Score

The MDS is an eight-component, 8-point measure of diet quality (Table 1.8). It is based mainly on food groups, and is supplemented with a ratio of the fatty acid composition of the diet (monounsaturated fatty acids (MUFAs) and SFAs) [1]. A high MDS score indicates a good diet quality.

A study by Lasheras et al. [33] evaluated the relationship between MDS and mortality among Spanish elderly. They found that the MDS was only significantly associated with a reduced risk of death in persons under 80 years [33]. Another study evaluating French adults was also reported to exhibit lower mortality following a Mediterranean diet in intervention studies [52, 53]. Furthermore, Osler and Schroll [31] found an association between plasma carotene and MDS. However, no association was reported between plasma cholesterol, high density lipoprotein (HDL), or vitamin E with the score [31].

Dietary patterns are influenced greatly by cultural differences. Thus, it is important to take into consideration these differences when choosing diet quality indices to measure diet quality of a certain population. Though the MDS may seem pertinent in predicting mortality, especially in European Mediterranean populations, it may be better to adapt or develop a score that tailors to local diets in Western populations, like the UK [3].

## Subjective and Non-scoring Systems

It is important to emphasize that many published studies employ the term *diet quality* or other aspects of *quality* without using indices or numerical scoring systems. Such studies may be subjective but based on a firm scientific foundation. For example, diets low in iodine may be deemed as *poor* or *low quality* as the consequences of iodine deficiency can be devastating. Iodine deficiency, for example, is well known to be associated with increased rates of stillbirths, spontaneous abortions, cretinism, hypothyroidism, impaired cognitive function, etc. This does not mean to say that the terms *poor* or *low quality* have been misused but rather they have been used within a different context. However, it is increasingly likely that the use of diet quality scoring systems will gain wider usage, and new ones developed as the scientific dialogue between diet and disease progresses.

**Table 1.8** Mediterranean Diet Score (MDS)

| Nutrient or food group | Scoring | |
|---|---|---|
| MUFA:SFA | >Median | 1 (else: 0) |
| Legumes | >Median | 1 (else: 0) |
| Cereals | >Median | 1 (else: 0) |
| Fruits and nuts | >Median | 1 (else: 0) |
| Vegetables | >Median | 1 (else: 0) |
| Meat and meat products | <Median | 1 (else: 0) |
| Milk and dairy products | <Median | 1 (else: 0) |
| Alcohol | <Median | 1 (else: 0) |

*Source*: Trichopoulou et al. [11]
*MUFA* monounsaturated fatty acid, *SFA* saturated fatty acid

## Conclusion

Diet quality is a subjective term that is often used within the context of a deficiency or excess of nutrients or foods. Attempts have been made to translate such subjectivity into objective measures, namely via scoring systems. Some of these scoring systems correlate with biomarkers, mortality, cognitive impairment, and other variables. On the other hand some studies are negative suggesting that the scoring systems may not be applicable to all situations or populations.

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