

# Does Measuring Diet Quality Help in Predicting Health Outcomes?

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## ABSTRACT

Measures of diet quality help to assess dietary risk factors for non-communicable diseases in nutritional epidemiology. This paper is a review of the methods used across the world to assess diet quality and their use in predicting health outcomes. In most studies on disease prevention importance has been given to the role of individual nutrients or food groups. In a day people eat a combination of food items and not individual foods in isolation. Although several diet quality indices have been developed, there is no universal diet quality index in use. Most indices adhere to national dietary guidelines. Scores in the diet quality indices have been correlated with cancer, coronary heart disease and other cardio-vascular diseases. Data from longitudinal studies provide better insights. The limitations of such studies are the short time duration to show a cause effect relation between diet quality and health outcomes.

**Keywords:** diet quality, diet variety, dietary scores, dietary indices, health outcomes

## INTRODUCTION

Diet includes the sum total of foods and beverages consumed by the individual. Quality of the diet is usually estimated by comparing intake of nutrients and different food groups to the recommended amounts. Variety and moderation have been two key elements of a healthy diet. A number of diet quality indices have been developed using national dietary guidelines as well as the WHO guidelines for prevention of non-communicable diseases. This review looks at the basis and merits of the different diet quality indices available and their ability to predict health outcomes.

The concept of diet quality has become popular in research, the term is broadly used but still there is no universally accepted definition of diet quality. [1] Some indices are based on current nutrition knowledge and some are derived from food

consumption data. They are increasingly being used to link diet and health outcomes and also to assess the adherence to nation specific dietary guidelines. They can have a predefined cut off pattern or a set scoring system by which they help to categorise populations as healthy and unhealthy. For formulation of diet quality indices, the purpose needs to be identified, and then accordingly the dietary method to be used and the dietary variables to be used are decided.

## METHODS

Literature search of scientific databases was done and published articles / reports related to diet quality were selected. Search engine like Google Scholar, Science Direct and Academic Info were used to retrieve relevant literature from databases like Scopus, PubMed, Medline, Springer

link and reports published by Food and Agriculture Organization (FAO) and World Health Organisation (WHO). The following keywords were used to search each database: 'diet quality', 'diet diversity', 'dietary scores', 'dietary indices', 'health outcomes' and names of diet related chronic diseases like 'cardiovascular disease', 'coronary heart disease' and 'cancer'. After screening 24 papers were selected for this review as they dealt with the use of different diet quality indices in different countries of the world. Papers published between the year 1995 and 2017 were only selected to provide data for the paper.

### **Basis**

Most diet quality indices are based on nation specific dietary guidelines (Table 1). Various indices have been designed based on the purpose and population for which it was developed. Healthy Eating Index (HEI) assesses the adherence to United States (US) food guide pyramid; Recommended Foods Score (RFS) assesses the adherence to Belgium dietary guidelines. Healthy Food and Nutrient Index (HFNI) aims to assess Belgium food intake pattern on the basis of national recommendations. Mediterranean Adequacy Index looks at how the population food intake meets reference Mediterranean dietary pattern. Some indices such as the Alternative Healthy Eating Index (AHEI) and Diet Quality Index-International (DQI-I) use cut offs similar to nation specific guidelines. Indices can then be used to measure alignment with national guidelines. Some diet quality indices are based on prevention of diseases. For instance: Diet Quality Index- Revised (DQI-R) is based on the risk of developing diet related non-communicable diseases. Different dietary survey tools have been used to collect data for various diet quality indices. Indices like the HEI, DQI and DQI- R have been assessed using the 24-hour recall method. Indices like the HFI, HFNI have used food record. Indices such as the AHEI, HFI, RFS, DQI, and MDS are based on data

collected using food frequency questionnaires.

Indices have variables to define scores, in some indices nutrients are used, in some food groups or a combination of both may be used. Indices that have food groups as their components are Food Based Quality Index (FBQI),<sup>[2]</sup> Healthy Food Index (HFI)<sup>[3,4]</sup> and Food Pyramid Index (FPI).<sup>[5]</sup> The adapted Diet Quality Index (DQI) uses nutrients as the variable for scoring. Some indices like the DQI-I and HEI include both food groups and nutrients.

### **Dietary variety**

Diet quality indices have been used in nutritional epidemiology. Diet quality index (DQI) was originally developed as an instrument for diet related chronic diseases.<sup>[6]</sup> The index was developed from diet and health guidelines for US population. It included eight variables i.e. total fat, saturated fat, cholesterol, fruit and vegetables, grains and legumes, protein, sodium, and calcium. It emphasised the need to limit fat to less than 30 percent of total calories, saturated fat to less than 10 percent of total calories and to reduce the cholesterol to less than 300mg per day and eating at least 5 servings of fruits and vegetables. The index had an additional component where the intake of starches and other complex carbohydrates was increased by six or more servings daily of breads, cereals and legumes. It however maintained protein intake level to moderate i.e less than half the RDA. Diet of the US population includes a lot of flesh foods and milk products, with protein accounting for 34.9% of the total calories.<sup>[7]</sup> A component of the index deals with maintaining levels of salt intake less than 6g.

Some Diet quality indices have a component of dietary variety in the index that describes the frequency at which different foods are consumed over a given time frame.<sup>[8]</sup> DQI was updated into the Diet Quality Index Revised (DQI-R) to account for variety, moderation and

proportionality. It includes ten components i.e. total fat, saturated fat, cholesterol, calcium, fruit, vegetable, grains, iron, dietary moderation and diversity. For each component a maximum score of 10 can be obtained. The maximum score an individual can obtain on DQI-R is 100. A study validating the DQI-R showed reproducibility of the DQI-R ( $r=0.72$ ) when scores obtained on two food frequency questionnaires were validated one year apart. The DQI-Revised showed direct correlation of the score with several plasma biochemical measurements of alpha-carotene ( $r = 0.43$ ), beta-carotene ( $r = 0.35$ ), alpha-tocopherol ( $r = 0.25$ ) and inverse correlation with plasma total cholesterol ( $r = -0.22$ ).<sup>[9]</sup> Seymour et al validated the Diet Quality Index by relating the overall score to mortality. They used a 68 item FFQ that was conducted on 63,109 women and 52,724 men aged 50-79 years.<sup>[10]</sup>

An index called the Diet Quality Index-International (DQI-I) has been used to assess diet quality across countries such as China and the United States. DQI-I includes various components like adequacy, variety, overall balance and moderation. The DQI-I scores were better for the Chinese population than the US population.<sup>[11]</sup> The US population scored better on the diet variety component while Chinese population scored better in moderation and overall balance categories. The DQI-I is helpful in providing information on areas of the diet which need improvement.

Over the course of time different Mediterranean Diet Scores have been developed with advancement in knowledge. Mediterranean Diet Score (MDS) – I assesses overall diet pattern using food frequency questionnaire. It is comprised of eight components cereal, legume, high monounsaturated to saturated fat ratio, vegetable, fruit, ethanol, milk and dairy consumption, meat and meat product consumption. Cut off points are based on median values for each component of the MDS. Scores range from 0-8, higher score indicating a better diet.<sup>[12]</sup> MDS- II assesses

the overall diet pattern based on traditional Mediterranean diet. The scale includes legumes, fruits/nuts, vegetables, cereals and fish. Fish is an added component in the MDS-II. The dietary assessment method used is food frequency questionnaire. A score of 1 is given if the nutrient value is above gender specific median cut off and 0 if the value is below median. For dairy, meat and poultry components, a score of 1 is given if intake is below median and 0 if above the median. The score range is between 0-9, with 9 indicating highest score and maximum adherence to the traditional Mediterranean diet.<sup>[13]</sup> In Mediterranean Diet Score (MDS) –III vegetable group was replaced by starch food group. The scores range from 0-7, with 7 indicating a better diet. The diet method used to calculate MDS-III is the 3 day food record and frequency checklist. Mediterranean Diet Score (MDS) –IV includes legumes, nuts, seeds, vegetable and potatoes, meat and poultry and fish. The scores range between 0-9, where higher score indicates a better diet quality. Diet history is the dietary method used in the MDS-IV.<sup>[14]</sup>

Studies have been done to establish a link between diet quality and health outcomes (Table 2). Indices have shown strong associations with mortality due to cancer and cardiovascular disease. Better index scores have been associated with reduction in risk of developing cardiovascular diseases. Studies showed that risk of developing cardiovascular disease was 28% lower in population having highest HEI-f score,<sup>[21]</sup> 39% lesser risk among men in the highest quintile of AHEI score<sup>[16]</sup> and 18% reduced risk in highest HDI score group.<sup>[23]</sup> Out of eight in total, six indices used food frequency questionnaires as the tool to measure diet quality. Food frequency questionnaire ranged from 26 to 150 food items list. In a study, DQS had no relationship with incidence of cancer.<sup>[20]</sup> This is because of the short study duration of 10 years. The limitation of most studies linking diet quality and health outcome was the short time duration to show a cause

effect relation between quality of diet consumed and health outcomes.

**Table 1: Overview of studies using diet quality indices**

S. No	Index	Objective	Components		Scoring and Interpretation	Dietary method used	Country (Reference)
			Nutrient	Food groups			
1	Healthy Eating Index (HEI)	Assess adherence to US Food Guide Pyramid	Overall fat %, energy, saturated fat %, energy, cholesterol, sodium	Grains, vegetables, fruit, meat, milk, variety in diet	Ten components each contributes 0–10 points. Components 1–5 based on conforming to serving recommendations. Score range: 0(worst)–100(best).	One day 24 h recall and 2 days food record	United States <sup>[15]</sup>
2	Alternative Healthy Eating Index (AHEI)	Assess whether AHEI is able to predict risk of disease better than HEI.	Percentage of trans fat, ratio of polyunsaturated fat to saturated fat.	Vegetables, fruit, nuts, ratio of white to red meat, cereal (fibre), alcohol	Nine components have 0–10 points each. Score of 10 indicates recommendations met and 0 indicates the least healthy dietary behaviour.	Food frequency questionnaire	United States <sup>[16]</sup>
3	Healthy Food Index (HFI)	Assess adherence of food intake patterns to US food recommendations		Margarine, butter or lard, vegetables, coarse rye, white bread, fruit	Four components, each receiving 1 point if met daily: Not consuming margarine, butter or lard; Consumption of boiled or raw vegetables; Consumption of coarse rye or white bread; Consumption of fruit at least once Score range 0–4. Score of 4 indicates better diet quality.	Food frequency questionnaire	United State <sup>[3]</sup>
4	Healthy Food and Nutrient Index (HFNI)	Assess adherence to Belgium dietary guidelines	Saturated fat, cholesterol, monounsaturated fat, polyunsaturated fat, protein, fibre, carbohydrates	Fruit and vegetables	Eight components, each receiving 1 point if consumption is within limit and 0 is awarded if consumption exceeds limit. Score range 0–8, with higher score indicating adherence to recommendations.	1 day food record	Belgium <sup>[17]</sup>
5	Diet Quality Index (DQI)	Assess adherence to WHO dietary recommendations for preventing chronic disease.	Total fat, saturated fat, cholesterol, protein, calcium, sodium	Vegetables and fruit, grains	Has 8 components, if diet: meets recommendation = 0 recommendation almost met=1 recommendation not met=2 Score range is 0–16 where 0 indicates excellent diet	24 hour recall and 2 day food record	United States <sup>[10]</sup>
6	Diet Quality Index Revised (DQI-R)	Assess adherence to US dietary guidelines	Total fat, saturated fat, cholesterol, protein, iron, sodium	Fruit and vegetables, dietary moderation and diversity	Has ten components that receive between 0–10 points. Score range: 0–100. Higher scores better diet quality.	24 hour recall	United States <sup>[9]</sup>
7	Diet Quality Score (DQS)	Assess adherence to Danish Dietary Guidelines	Total fat	Fish, fruit and vegetables	Has four components, each component can get a maximum score of 3 points. very unhealthy =1 point average intake =2 points very healthy =3 points Points range = 1-12, where a score of 12 is most healthy.	Food frequency questionnaire	Denmark <sup>[18]</sup>

**Table 2: Associations between diet quality and diet related chronic diseases**

S. No.	Study and reference	Index	Dietary method	Country	Study population	Main outcome	Key findings	Limitations
1	Schatzkin et al. 2000 <sup>[19]</sup>	RFS	62-item FFQ	USA	42254 women (mean age 61 years).	Mortality due to cancer	High RFS score is associated with reduced mortality risk in women (RR=0.69, 95% CI, p<0.001)	Lack of diversity in sample
2	Fitzgerald et al. 2002 <sup>[20]</sup>	DQS	24 h recall	Canada	2108 adults (18–74 years).	Cancer incidence	Highest DQS quintile showed no association with cancer incidence (multivariate adjusted odds ratio 0.81, p=0.41)	Short study duration
3	Osler et al. 2002 <sup>[4]</sup>	HFI	26-item FFQ	Denmark	7316 adults (30–70 years).	Mortality due to Coronary heart disease	High HFI score is associated with reduced mortality due to coronary heart disease (hazard ratio estimate is 0.94)	Short food frequency questionnaire
4	Trichopoulou et al. 2003	MDS-II	150-item FFQ	Greece	22043 adults (20–86 years).	Mortality due to cancer and coronary heart disease	High MDS-II scores associated with reduced mortality caused by coronary heart disease (0.67; 95% CI 0.47-0.94) and cancer (0.76, 95% CI 0.59 to 0.98)	Presence of unevaluated confounding factors
5	Seymour et al. 2003 <sup>[10]</sup>	DQI	68-item FFQ	USA	52724 men and 63109 women (50–79 years), American Cancer Society Cancer Prevention Study II Nutrition Cohort.	Mortality due to circulatory disease	Positive association with mortality due to circulatory disease in women (1.86; 95% CI)	Short follow-up period for mortality outcome
6	McCullough et al. 2000 <sup>[21]</sup>	HEI-f	131-item FFQ	USA	51529 men aged 40–75 years. (Health professionals Follow-Up Study)	Cardiovascular disease incidence	High HEI-f score was associated with reduction in cardiovascular risk by 14 % (RR=0.86; 95% CI: 0.72-1.03).	Short study duration, lack of diversity in sample
7	Huijbregts et al. 1997 <sup>[22]</sup>	HDI	Diet history	Netherlands	3045 men (50–70 y); 20 years follow up.	Mortality disease risk due to cardiovascular disease	High HDI score was associated with lower risk of mortality due to cardiovascular disease in males (RR=0.56; p=0.03)	Lack of diversity in cohort
8	McCullough et al. 2002 <sup>[16]</sup>	AHEI	130-item FFQ	USA	67271 women and 38615 men. (Health Professionals' Follow-Up Study and Nurses' Health Study)	Cardiovascular disease incidence	High AHEI score was associated with significant reduced risk for CVD in men (RR=0.61) and in women (RR=0.72)	Lack of diversity in cohort

\* RFS: Recommended Food Score; DQS: Diet quality score; HFI: Healthy Food Index; MDS-II: Mediterranean Diet Score II; DQI: Diet Quality Index; HEI-f: healthy eating index-food-frequency questionnaires; AHEI: Alternative Healthy Eating Index; HDI: Healthy Diet Indicator

The US Department of Agriculture developed the 'healthy eating index' in an effort to track outcomes of health promotion activities. It is a 10-component indicator of how well American diets conform to the

dietary guidelines and the food guide pyramid. Healthy Eating Index was found to be strongly associated ( $r=0.71$ ) with dietary variety and moderately with higher plasma concentrations of alpha-carotene ( $r = 0.40$ ),

beta-carotene ( $r = 0.28$ ) and beta-cryptoxanthin ( $r = 0.41$ ).<sup>[15]</sup> The Alternative Healthy Eating Index (AHEI), an updated version gained more popularity. AHEI included components of multivitamin use, ratio of white meat to red meat, fruits and vegetables as separate categories, nuts and soy protein, cereal and fibre which were each given a separate category. AHEI comprises of items that are protective in case of cardiovascular disease, like the ratio of PUFA to SFA. In a study it was reported that men who had good diet quality score on the AHEI were at 11% lower risk of overall chronic disease risk when highest quintile was compared with the lowest quintile. The alternative Healthy Eating Index was inversely associated with major chronic disease risk (cardiovascular disease and cancer) in men and women ( $r=0.8$  and  $0.89$  respectively).<sup>[16]</sup>

Healthy Diet Indicator(HDI) developed according to the WHO Guidelines on Prevention of Chronic Diseases has been reported to be inversely associated ( $r= - 0.87$ ) with all-cause mortality in pooled population from three European countries, namely, Netherlands, Italy, Finland. Reported risk reductions were relatively small (13 %) for Dutch elderly but considerably higher (44 %) for Italian men.<sup>[22]</sup> The HDI was not associated with waist circumference.<sup>[23]</sup>

## CONCLUSION

This paper presents a comprehensive review of the methods of measuring diet quality and its association with health outcomes. Diet quality indices are constructed with a pre-defined purpose. Diet quality indices like the HEI, RFS, DQI-I assess the adherence to nation specific dietary guidelines. Components of diet quality indices differ from each other in terms of food groups and nutrients selected. Indices which include a variety of both food groups and nutrients are helpful in providing information on components like adequacy, variety, overall balance and moderation. Indices are often revised from their original

versions to keep up with change in knowledge. For instance: the Diet Quality Index was updated to Diet Quality Index-Revised and then to Diet Quality Index-International. The Mediterranean Diet Scores have also been modified from time to time and there are four versions.

Several indices have established link between mortality and diseases such as cancer, stroke, ischemic heart disease, coronary heart disease and circulatory diseases. Studies have also suggested that maintaining a good score on some of these indices is related to a lower risk of developing cardiovascular diseases. However, short study duration and lack of diversity in the study population have been identified as limitations of these studies. There is a need for a universally accepted index which can be used for comparing diet quality among nations. The Diet Quality Index-International (DQI-I) has been used to assess diet quality across countries such as China and United States. It needs to be validated in more countries across the globe. An internationally validated tool would be invaluable in predicting health outcomes based on current dietary patterns and hence have an important role to play in prevention of diet-related non-communicable diseases. It would make comparison of diet quality across countries more meaningful.

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## Conflicts of Interest

The authors report no conflict of interest towards production of the article.

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