Review Article

# Dietary pattern analysis for the evaluation of dietary guidelines

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Dietary Guidelines for the promotion of overall good health and the prevention of disease often play an important role in setting nutritional policy and in the education of the public about healthy food choices. Although much has been written about adherence to such guidelines, until recently there was no evidence on whether adherence to specific dietary guidelines is associated with better health. As an outcome variable for such analyses, we have used the incidence of major chronic disease, which includes incidence of any major cardiovascular disease, cancer, or death from any cause excluding violence. We have evaluated the Dietary Guidelines for Americans using a scoring system called the Healthy Eating Index developed by the Department of Agriculture to quantify adherence to these guidelines. We found that adherence to the Dietary Guidelines and the Food Guide Pyramid was associated with only a small reduction in major chronic disease risk in a population of over 100,000 US adult men and women. We also assessed whether an alternate index, which took into account the type of fat and quality of carbohydrate, would better predict risk. In contrast with the original Healthy Eating Index, adherence to the alternative index predicted lower rates of major chronic disease, and particularly cardiovascular disease, suggesting that the Dietary Guidelines were not offering optimal dietary guidance. These analyses suggest that dietary guidelines should be evaluated for their ability to predict the occurrence of major illness, and that such analyses can help refine these guidelines.

**Key Words: dietary, nutrition, guidelines, pattern, index**

## INTRODUCTION

Dietary guidelines have been developed by many groups, including the World Health Organization, most national governments, and other organizations concerned with specific diseases such as cancer or heart disease. These guidelines are intended to provide education for the public about healthy food choices, and are also often used by governments for setting nutrition policies and by institutions in planning menus. Ideally, they would also guide agricultural and economic policies. These uses can reinforce each other and have an important effect on the health of a population; it is thus important that dietary guidelines be based on the best available evidence and that they be evaluated rigorously. As the goal of dietary guidelines is to promote better health, the most direct way to evaluate them is to determine whether adherence to the guidelines predicts better health. In theory, an evaluation might be conducted by randomizing large numbers of people to a dietary pattern consistent with a set of guidelines or to a control diet (such as the existing diet of a population) and following the population for overall health outcomes. The Women's Health Initiative was an attempt to conduct such a trial in over 48,000 women, in which the intervention was a "low fat eating pattern" that was intended to include high amounts of fruits, vegetables, and whole grains.[1,2]

This massive study resulted in no significant results for overall mortality of any of the disease-specific endpoints, but the interpretation was muddied by low compliance with the diet being evaluated. Randomized trials of dietary patterns are more feasible using outcomes such as blood pressure because they can be conducted over short periods of months, rather than years, and in much smaller groups of people; the DASH study is an example.[3] Although very useful, such trials provide only a limited view of health outcomes as they do not address incidence of cardiovascular disease (CVD), cancer, or mortality. Because of these limitations, the evaluation of dietary patterns in relation to incidence of major health outcomes in large prospective studies can provide critical information about the value of dietary guidelines.

### *Defining adherence to dietary patterns*

A critical step in assessment of adherence to a dietary guideline is the development of an operational definition of adherence.

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An important example of this was creation of the Healthy Eating Index HEI) by Kennedy *et al*.[4] that was designed to measure adherence to the 1995 Dietary Guidelines for Americans and the US Food Guide Pyramid (its visual counterpart). This 10-component, 100-point score measured how well the diets of Americans conform to recommendations for consumption of foods from five food groups, as well as guidelines on fat, cholesterol, sodium, and dietary variety.

The 1995 Dietary Guidelines for Americans focused on reduction of total fat with little distinction among types of fat or among forms of carbohydrate. Because the available data provided little evidence that the percentage of total fat in the diet was related to major health outcome, but that the types of fat, forms of carbohydrate, and sources of protein had important influences on risks of CVD and type 2 diabetes, we developed an Alternative Healthy Eating Index (AHEI) that took into account these factors.[5-7]

Another example is the Mediterranean dietary pattern score developed by Trichopolou *et al*.[8] which is an attempt to describe operationally adherence to the way of eating of populations living in an area characterized by unusual longevity. These dietary pattern indices are described further in table 1. Notably, they are a priori indices that have been designed to characterize quantitatively adherence to a set of existing guidelines, or alternatives to these guidelines, based on knowledge of nutrition and human biology, in contrast to dietary pattern scores that are derived empirically by methods such as factor analysis. Also, it is notable that all of these dietary pattern scores include components based on both foods and nutrients. The use of only food-based components is attractive in principle, but in reality the same foods can be prepared in many different ways, for example using healthy or unhealthy forms of fat, refined or whole grain carbohydrates, and highly variable amounts of salt. Thus, variables such as unsaturated fats, cereal fiber, and sodium can be important to quantify in addition to using food groups such as fruits and vegetables.

### *Application of dietary pattern scores*

Once a dietary pattern score has been developed, it can be used to quantify the adherence of individuals according to the specific set of dietary guidelines being evaluated. The primary data can be obtained by short-term methods, such as 24-hour recalls, dietary records, or by food frequency questionnaires. Each of these methods has its strengths and weakness, discussed elsewhere,[9] but for assessment of long-term intakes of individuals in epidemiological studies, food frequency questionnaires have major practical advantages. The pattern score can be used in many ways, such as in descriptive studies documenting the percentage of persons adherent to the guidelines, the compliance with dietary interventions, or the relation of adherence to the occurrence of health outcomes. The latter provides a direct evaluation of whether the dietary guidelines are worthy objectives.

### *Choice of outcomes*

Dietary guidelines are generally designed to promote overall good health, which would include reducing the major causes of morbidity and mortality in a population. For this reason, a global outcome variable, rather than incidence of a specific disease, is usually desirable, although valuable insights can be gained using specific diseases or conditions such as hypertension as outcomes. Although total mortality is conceptually an attractive outcome, in reality it is often a particularly problematic outcome because of reverse causation (people often die after a long illness that could affect their diets), uncontrolled confounding (because detailed data on screening and treatment of incident disease are often not available), and important causes of morbidity are not included. For this reason we have used incidence of major chronic disease as an endpoint; we included incidence of any cancer (except nonmelanoma skin cancer), myocardial infarction, stroke, or death from other causes except violence, but other definitions are possible.

### *Examples of applications*

We previously tested whether having higher HEI scores predicted lower chronic disease risk in two large cohorts of men and women in the US. The score weakly predicted major chronic disease risk in men, but not in women.[6,7] Men whose diets fell into the highest HEI quintile (vs.

**Table 1.** Qualitative comparison of the HEI, AHEI, and the Mediterranean Diet index[†]

| Component | HEI[‡] | Alternate HEI[§] | Mediterranean[¶] |
|---|---|---|---|
| **Dairy Products** | ↑ | - | ↓ |
| ***Vegetables*** | ↑ | ↑ (no potatoes) | ↑ |
| Fruit | ↑ | ↑ | ↑ |
| ***Nuts, Seeds*** | ↑ (w/ meat) | ↑ | ↑ (w/ fruit) |
| Bread/CHO | ↑ | ↑ cereal fiber | ↑ |
| Meat, Poultry & Fish | ↑ | ↑ fish/poultry to red meat ratio | ↓ meat & poultry; ↑fish |
| Cholesterol | ↓ | - | - |
| Fat | ↓ tot & SF | ↑ P:S ratio<br>↓ trans fat | ↑ M:S ratio |
| Sodium | ↓ | - | - |
| Alcohol | - | ↑ moderate | ↑ |
| Multivitamins | - | ↑ | - |

[†] Arrows indicate general direction of recommended intake; parentheses provide additional details on scoring method, for example where the component is included in the overall diet score. [‡] Kennedy, *et al*[4]; [§] McCullough, *et al*[5] ; [¶] Trichopolou, *et al*[8]

**Table 2.** Relative risk (RR) and 95% confidence intervals of major chronic disease, cardiovascular disease and cancer in men and women according to the Alternate Healthy Eating Index (AHEI)

| | Quintiles of AHEI scores | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | *p* trend[†] |
| Major chronic disease[‡] | | | | | | |
| Men: RR[§] | 1.0 | 0.96 (0.86-1.07) | 0.88 (0.79-0.99) | 0.79 (0.71-0.89) | 0.80 (0.71-0.91) | <0.001 |
| Women: RR[§] | 1.0 | 0.97 (0.90-1.04) | 0.92 (0.88-0.99) | 0.95 (0.87-1.02) | 0.89 (0.82-0.96) | 0.009 |
| Cardiovascular disease[¶] | | | | | | |
| Men RR[§] | 1.0 | 0.85 (0.71-1.00) | 0.79 (0.66-0.95) | 0.67 (0.56-0.81) | 0.61 (0.49-0.75) | <0.001 |
| Women RR[§] | 1.0 | 0.95 (0.82-1.11) | 0.80 (0.68-0.94) | 0.75 (0.63-0.89) | 0.72 (0.60-0.86) | <0.001 |
| Cancer[¥] | | | | | | |
| Men RR[§] | 1.0 | 1.10 (0.94-1.28) | 0.99 (0.85-1.16) | 0.94 (0.80-1.10) | 1.03 (0.87-1.22) | 0.66 |
| Women RR[§] | 1.0 | 0.94 (0.86-1.03) | 1.03 (0.95-1.13) | 1.04 (0.95-1.13) | 1.00 (0.92-1.11) | 0.39 |

[†] *p* value, test for trend over quintiles of index scores using the median value per quintile. [‡] Major chronic disease=CVD, cancer, or death, whichever came first. [§] Adjusted for age (5-year categories), smoking (never, past, 1-14 cigarettes per day, 15 to 24 cigarettes per day, >25 cigarettes per day), time period, body mass index (quintiles), physical activity (six categories of METs), total energy intake (quintiles), postmenopausal hormone use (women), and, in all except cancer models, history of hypertension or hypercholesterolemia at baseline. The CVD model includes vitamin E. [¶] Cardiovascular disease=fatal or non fatal myocardial infarction, stroke, or sudden death. [¥] Cancer=all cancers except non-malignant skin cancers, *in situ* breast cancers and non-aggressive prostate cancers

lowest) were at 11% lower risk of overall chronic disease (RR=0.89, 95% CI, 0.79-1.00) but women were not at lower risk (RR=0.97, 95% CI, 0.89-1.06). A statistically significantly lower risk of CVD was observed in men with the highest HEI scores (RR=0.72, 95% CI, 0.60-0.88) but the association was weaker in women (RR=0.86, 95% CI, 0.72-1.03). The score did not predict cancer risk in men or women.

Because of the limitations of the HEI, we developed the Alternate Healthy Eating Index (AHEI) described above, and evaluated its relation to incidence of major chronic disease in the same cohorts[5] (see table 2**).** Among men, after controlling for smoking and other known risk factors, we observed a moderate inverse relation with overall major chronic disease (RR=0.80, 95% CI, 0.71-0.91, $p < 0.001$). Adjusting for other risk factors, men with highest AHEI scores had a 39% lower CVD risk than those with lowest scores (RR=0.61, 95% CI, 0.49-0.75); however, the AHEI did not predict cancer risk. The overall findings for women were weaker than for men, but the AHEI predicted a significant reduction in major chronic disease risk in our multivariate models (RR=0.89, 95% CI, 0.82-0.96, $p = 0.009$). Highest (compared to lowest) AHEI scores were related to a 28% lower CVD risk in women (RR=0.72, 95% CI, 0.60-0.86, $p < 0.001$). Again, we observed no association between AHEI and cancer risk in women.

Greater adherence to the Mediterranean Dietary Index predicted lower mortality and lower rates of cancer and CVD in a Greek population.[8] Also, a version of this score modified for non-Mediterranean populations has predicted important health outcomes in other populations.[8,10,11] The development of dietary guidelines should be regarded as an ongoing process that will be influenced by new information on health and disease, trends in the food supply, and changing patterns of disease. Evaluations of dietary guidelines should be an important part of this iterative process because the findings can be used to improve existing guidelines. A useful part of this process can be to examine the individual components of the dietary indices in relation to disease outcomes to identify those that are most or least informative. Since our evaluation of the 1995 Dietary Guidelines for Americans, these guidelines have been updated in 2000 and 2005. The 2005 modifications moved substantially in the direction of the AHEI, and a new index to evaluate adherence to these guidelines has been developed that includes 20 components based on foods and nutrients.[12] A thorough evaluation of this new index in relation to major chronic disease will be important.

## CONCLUSION

Dietary Guidelines should be evaluated for their ability to predict the occurrence of major illness, and such analyses can help refine these guidelines. Evaluations of dietary guidelines will be important in Asian populations because the range of dietary variables is sometimes beyond those of western populations and patterns of physical activity and genetic susceptibility may be different.

**AUTHOR DISCLOSURES**

Walter C Willett and Marjorie L McCullough, no conflicts of interest.

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