



United States Department of Agriculture

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# A Series of Systematic Reviews on the Relationship Between Dietary Patterns and Health Outcomes

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# Executive Summary

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Consuming a healthy diet can help individuals achieve and maintain a healthy weight, reduce the risk of developing chronic diseases, and promote good health. Research in the field of nutrition often focuses on single nutrients, foods, and/or food groups. While looking at components of the diet individually is important to examine the effects of various aspects of the diet on health, foods and nutrients are eaten in a variety of combinations and can have interactive and potentially cumulative or confounding relationships. Thus, when developing guidance on the types of foods, beverages, and nutrients to consume, it is important to consider research on individual components of the diet, as well as research that examines dietary patterns. For the purpose of this systematic review project, a dietary pattern is defined as the quantities, proportions, variety, or combination of different foods, drinks, and nutrients (when available) in diets, and the frequency with which they are habitually consumed. As noted in the *2010 Dietary Guidelines for Americans*,<sup>1</sup> there are several ways that a healthy diet can be achieved. The purpose of this project was to examine the relationship between dietary patterns and outcomes of public health concern.

## Background and Methodology

USDA's Nutrition Evidence Library (NEL) conducted these systematic reviews. The NEL uses a rigorous, transparent, and reproducible methodology to conduct systematic reviews on food- and nutrition-related topics to support Federal nutrition policies and programs. The six-step process includes:

1. Systematic review question development
2. Literature search, screening, and selection
3. Data extraction and quality assessment
4. Describing the evidence and evidence synthesis
5. Developing conclusion statements and grading the evidence
6. Identifying research recommendations.

This NEL systematic review project was planned, organized, and guided by a NEL Systematic Review Management Team composed of Federal nutritionists trained in systematic review methodology. The NEL Systematic Review Management Team worked with a Technical Expert Collaborative (TEC) that consisted of seven national nutrition experts with knowledge in various aspects of dietary patterns. A broad range of expertise was needed to address specific issues related to the topic of dietary patterns and to guide synthesis of the body of evidence to answer the systematic review questions posed. A Stakeholder Group, which included Federal employees who represented end-users of the review and possessed varying perspectives and expertise related to dietary patterns, provided input throughout the process.

## Systematic Review Questions

At the initiation of the project, the NEL held a workshop with the TEC members, Stakeholder Group, and invited speakers to discuss the various methodologies used to assess dietary patterns and to help inform the approach for the project. Following the workshop, the TEC identified and prioritized specific systematic review questions addressing dietary patterns and outcomes of public health concern. The NEL Systematic Review Management Team helped to focus the questions on outcomes of public health importance that could potentially inform Federal nutrition policies and programs. The questions were also reviewed by the Stakeholder Group to ensure that they were relevant to policy needs.

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<sup>1</sup> U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans, 2010*. 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010.

The systematic review questions included in this project were organized based on (1) dietary pattern methodology and (2) health outcomes:

- **Dietary pattern methodology:** Dietary patterns can be assessed in a number of ways, including numerical indices designed to gauge adherence to a particular pattern (e.g., Healthy Eating Index [HEI]) or data-driven approaches that use mathematics to empirically derive food intake patterns inherent among the study population (e.g., factor or cluster analysis) (appendix A). Dietary patterns can also be tested in trials or observed in observational studies. Because each methodology provides information about dietary patterns from a different perspective, the systematic review questions included in this project were organized based on dietary pattern assessment: (1) index analysis, (2) factor/cluster analysis, (3) reduced rank regression, and (4) other methods.
- **Health outcomes:** The TEC identified three top priority outcomes for consideration: (1) body weight and obesity, (2) cardiovascular disease, and (3) type 2 diabetes. For each outcome, specific intermediate and clinical outcomes were defined (appendix B). A fourth outcome, cancer, was also identified but was not completed.

In total, 12 systematic review questions were completed in this project:

### **Body Weight or Risk of Obesity**

1. What is the relationship between adherence to dietary guidelines/recommendations or specific dietary patterns, assessed using an index or score, and body weight or risk of obesity?
  - *A priori* index
2. Are prevailing patterns of diet behavior in a population related to body weight or risk of obesity?
  - Factor analysis, principal component analysis; cluster analysis
3. What combinations of food intake explain the most variation in a risk of obesity?
  - Reduced rank regression; discriminant analysis
4. What is the relationship between adherence to a specific dietary pattern and body weight or risk of obesity?
  - Included studies that did not use the methodologies captured in the other systematic review questions

### **Risk of Cardiovascular Disease**

5. What is the relationship between adherence to dietary guidelines/recommendations or specific dietary patterns, assessed using an index or score, and risk of cardiovascular disease?
  - *A priori* index
6. Are prevailing patterns of diet behavior in a population related to risk of cardiovascular disease?
  - Factor analysis, principal component analysis; cluster analysis
7. What combinations of food intake explain the most variation in a risk of cardiovascular disease?
  - Reduced rank regression; discriminant analysis
8. What is the relationship between adherence to a specific dietary pattern and risk of cardiovascular disease?
  - Included studies that did not use the methodologies captured in the other systematic review questions

### **Risk of Type 2 Diabetes**

9. What is the relationship between adherence to dietary guidelines/recommendations or specific dietary patterns, assessed using an index or score, and risk of type 2 diabetes?
  - *A priori* index
10. Are prevailing patterns of diet behavior in a population related to risk of type 2 diabetes?
  - Factor analysis, principal component analysis; cluster analysis
11. What combinations of food intake explain the most variation in a risk of type 2 diabetes?
  - Reduced rank regression; discriminant analysis
12. What is the relationship between adherence to a specific dietary pattern and risk of type 2 diabetes?
  - Included studies that did not use the methodologies captured in the other systematic review questions

## Literature Selection

A broad range of studies assessing dietary patterns were considered in order to answer the systematic review questions. PubMed, Embase, Navigator (BIOSIS, CAB Abstracts, and Food Science and Technology Abstracts), and Cochrane databases were searched for original research articles published in English in peer-reviewed journals. Studies published since January 1980 with subjects who were healthy or at elevated chronic disease risk from countries with high or very high scores on the Human Development Index,<sup>2</sup> a measure of social and economic development, were considered. Study designs included in the review were randomized and nonrandomized controlled trials, including crossover studies, and prospective cohort studies. Cross-sectional studies, before and after studies, case-control studies, and reviews were excluded. Reviews were hand-searched for relevant primary research studies. Trials were required to have  $\geq 30$  subjects per arm and a follow-up of  $\geq 80$  percent. Studies that examined low-calorie diets and other treatment diets were excluded. Finally, studies were required to include a description of the foods and beverages eaten by study participants. The searches resulted in a total of 23,403 citations. Of these, 2,921 articles underwent dual abstract review, and a total of 176 articles met all of the criteria and were included in the reviews.

## Description of the Evidence

The evidence considered in this systematic review project was diverse. The number of articles included in each review varied, with 5 reviews including less than 10 articles, 6 reviews including 11 to 22 articles, and 1 review including 55 articles. Studies were conducted around the world, including the United States, Europe, Japan, and Australia, and ranged in sample size from 49 to over 380,000. Most studies were conducted in adults, with few studies available that examined dietary patterns in children or adolescents. The preponderance of evidence was from large prospective cohort studies; although some well-controlled randomized controlled trials were also included. The prospective cohort studies generally examined the relationship between dietary patterns and clinical health outcomes, while the trials often considered intermediate outcomes. Dietary intake was most often assessed with food frequency questionnaires, and in many studies, dietary intake was only assessed at baseline. Most articles were rated positive-quality, with fewer articles of neutral-quality. No negative-quality articles were included in the reviews.

## Conclusion Statements

Following a qualitative review of the evidence, conclusions were drawn and the strength of the body of evidence supporting the conclusion statement was graded. More robust evidence was available for the questions examining the relationship between dietary patterns and risk of cardiovascular disease. Moderate evidence supported conclusions related to dietary patterns and body weight or risk of obesity, while limited evidence was available related to dietary patterns and risk of type 2 diabetes.

Across the methodologies, the strongest, most consistent evidence was from positive-quality cohort studies using an *a priori* index or score and randomized controlled trials testing specific patterns. For all three of the questions that considered studies using factor or cluster analyses, limited conclusions were drawn primarily due to the variability in the dietary patterns identified in these studies, which made comparisons challenging. Similarly, the disparate nature of the studies that used reduced rank regression to assess dietary patterns made it difficult to compare results, and no conclusions could be drawn related to the relationship between dietary patterns and health outcomes using reduced rank regression.

Overall, not one specific dietary pattern was found to be more favorably associated with health outcomes. Rather, several dietary patterns were shown to be beneficial in reducing the risk of cardiovascular disease, obesity, and/or type 2 diabetes. The patterns that were most consistently associated with positive health outcomes were Mediterranean-style, Dietary Approaches to Stop Hypertension (DASH), and Dietary Guidelines-related patterns. Over the course of the review, the Technical Expert Collaborative and the Systematic Review Management Team noted that there were not universal definitions for these and other dietary pattern labels or for terms that were often

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<sup>2</sup> United Nations Development Programme. 2011 Human Development Reports. Available at <http://hdr.undp.org/en>.

found in this literature, including plant-based, nutrient-dense, or minimally processed. For example, a Mediterranean diet may vary somewhat from study to study, and a vegetarian pattern is typically defined based on what is excluded from the diet, rather than what is consumed. As such, the review conclusion statements were stated in terms of the food components observed consistently across the dietary patterns, rather than focusing on the label of the pattern. Additionally, the team found that the meaning of terms, such as low, moderate, and high, used to describe levels of food group, component, or nutrient intakes varied somewhat across studies. For example, low might mean lower than median intake, lower than recommended intake levels, or lower than the typical American or population intake. Depending on the body of included literature for each systematic review question, usage of these terms in this report's conclusion statements and key findings may represent a composite of these meanings.

## **Dietary Patterns and Risk of Cardiovascular Disease**

Dietary patterns associated with decreased risk of cardiovascular disease were characterized by regular consumption of fruits, vegetables, whole grains, low-fat dairy, and fish and were low in red and processed meat and sugar-sweetened foods and drinks. Regular consumption of nuts and legumes and moderate consumption of alcohol were also shown to be beneficial in most studies. Additionally, research that included specific nutrients in their description of dietary patterns indicated that patterns that were low in saturated fat, cholesterol, and sodium and rich in fiber and potassium may be beneficial for reducing cardiovascular disease risk.

### **Conclusion Statements: Dietary Patterns and Risk of Cardiovascular Disease**

#### **Strong or Moderate Evidence:**

There is strong and consistent evidence that in healthy adults increased adherence to dietary patterns scoring high in fruits, vegetables, whole grains, nuts, legumes, unsaturated oils, low-fat dairy, poultry, and fish; low in red and processed meat, high-fat dairy, and sugar-sweetened foods and drinks; and moderate in alcohol is associated with decreased risk of fatal and non-fatal cardiovascular diseases, including coronary heart disease and stroke. (Grade: I - Strong) (Index Analysis)

There is strong and consistent evidence that consumption of a DASH diet results in reduced blood pressure in adults with above optimal blood pressure, up to and including stage 1 hypertension. A dietary pattern consistent with the DASH diet is rich in fruits, vegetables, low-fat dairy, fish, whole grains, fiber, potassium, and other minerals at recommended levels, and low in red and processed meat, sugar-sweetened foods and drinks, saturated fat, cholesterol, and sodium. There is limited evidence that adherence to vegetarian diets is associated with decreased death from ischemic heart disease, with the association being stronger in men than in women. (Grade: I - Strong - DASH and Blood Pressure; Grade: III - Limited - Vegetarian and Ischemic Heart Disease) (Other Methods)

#### **Limited or Insufficient Evidence:**

Limited evidence from epidemiological studies indicates that dietary patterns, assessed using cluster or factor analysis, characterized by vegetables, fruits, whole grains, fish, and low-fat dairy products are associated with decreased risk of cardiovascular disease in adults. Evidence of a relationship between dietary patterns characterized by red and processed meat, sugar-sweetened foods and drinks, and fried foods and an increased risk of cardiovascular disease is limited and less consistent. (Grade: III - Limited) (Cluster or Factor Analysis)

Insufficient evidence, due to a small number of studies, was available to examine the relationship between dietary patterns derived using reduced rank regression and risk of cardiovascular disease. The disparate nature of the methods used made it difficult to compare results, and therefore, no conclusions were drawn. (Grade: IV - Not Assignable) (Reduced Rank Regression)

## **Dietary Patterns and Body Weight or Risk of Obesity**

More favorable outcomes related to body weight or risk of obesity were observed when there was increased adherence to a diet that emphasized fruits, vegetables, and whole grains. Some studies also reported more favorable body weight status over time with regular intake of fish and legumes, moderate intake of dairy products (particularly low-fat dairy) and alcohol, and low intake of meat (including red and processed meat), sugar-sweetened foods and drinks, refined grains, saturated fat, cholesterol, and sodium.

### **Conclusion Statements: Dietary Patterns and Body Weight or Risk of Obesity**

#### **Moderate Evidence:**

There is moderate evidence that in adults increased adherence to dietary patterns scoring high in fruits, vegetables, whole grains, legumes, unsaturated oils, and fish; low in total meat, saturated fat, cholesterol, sugar-sweetened foods and drinks and sodium; and moderate in dairy products and alcohol is associated with more favorable outcomes related to body weight or risk of obesity, with some reports of variation based on gender, race, or body weight status. (Grade: II - Moderate) (Index Analysis)

There is moderate evidence that adherence to a dietary pattern that emphasizes vegetables, fruits, and whole grains is associated with modest benefits in preventing weight gain or promoting weight loss in adults. (Grade: II - Moderate) (Other Methods)

#### **Limited or Insufficient Evidence:**

Limited and inconsistent evidence from epidemiological studies examining dietary patterns derived using factor or cluster analysis in adults found that consumption of a dietary pattern characterized by vegetables, fruits, whole grains, and reduced-fat dairy products tends to be associated with more favorable body weight status over time than consumption of a dietary pattern characterized by red meat, processed meats, sugar-sweetened foods and drinks, and refined grains. (Grade: III - Limited) (Factor or Cluster Analysis)

There are a number of methodological differences among the studies examining the relationship between dietary patterns derived using reduced rank regression and body weight status. The disparate nature of these studies made it difficult to compare results, and therefore, no conclusions were drawn. (Grade: IV - Not Assignable) (Reduced Rank Regression)

## Dietary Patterns and Risk of Type 2 Diabetes

The bodies of evidence examining the relationship between dietary patterns and risk of type 2 diabetes were limited or insufficient, but they generally supported consumption of a dietary pattern rich in fruits and vegetables and low in high-fat dairy and meats.

### Conclusion Statements: Dietary Patterns and Risk of Type 2 Diabetes

#### Limited or Insufficient Evidence:

There is limited evidence that adherence to a dietary pattern rich in fruits, vegetables, legumes, cereals/whole grains, nuts, fish, and unsaturated oils and low in meat and high-fat dairy, assessed using an index or score, is associated with decreased risk of type 2 diabetes. (Grade: III - Limited) (Index Analysis)

Limited and inconsistent evidence from epidemiological studies indicates that in adults, dietary patterns derived using factor or cluster analysis, characterized by vegetables, fruits, and low-fat dairy products tend to have an association with decreased risk of type 2 diabetes and those patterns characterized by red meat and sugar-sweetened foods and drinks, French fries, refined grains, and high-fat dairy products tended to show an increased association for risk of type 2 diabetes. Among studies, there was substantial variation in food group components and not all studies with similar patterns showed significant association. (Grade: III - Limited) (Factor or Cluster Analysis)

There is insufficient evidence on a relationship between adherence to a Mediterranean-style or vegetarian diet pattern and incidence of type 2 diabetes. There is limited, inconsistent evidence that adherence to a Mediterranean-style, DASH or modified DASH, or Nordic dietary pattern results in improved glucose tolerance and insulin resistance. (Grade IV - Not Assignable - Incidence of type 2 diabetes; Grade: III – Limited - Glucose tolerance and insulin resistance) (Other Methods)

There is insufficient evidence, due to a small number of studies, to examine the relationship between dietary patterns derived using reduced rank regression and risk of type 2 diabetes. The differences in the methods used and populations studied made it difficult to compare results, and therefore no conclusions were drawn. (Grade: IV - Not Assignable) (Reduced Rank Regression)

## Limitations and Research Recommendations

The systematic reviews highlighted overarching limitations in the research on dietary patterns. The following limitations and research recommendations were identified:

- Many studies only assessed dietary intake once at baseline. Dietary patterns are likely to change over time due to a myriad of factors, including trends in the food supply, population and individual-level changes in food choices, and individual circumstances and physical needs. Future studies that examine dietary patterns over time in relation to the life course would be beneficial to understand the relationship between dietary patterns, critical periods of exposure, and health.
- There was variability in how studies grouped foods and assessed the types and amounts of foods consumed; therefore, it was difficult to compare food and beverage intakes across studies. Additional research is needed to better quantitate the components of dietary patterns.
- A number of studies, particularly studies examining vegetarian diets, were excluded from the reviews because they did not provide sufficient description of the dietary pattern consumed. Complete description of the foods and beverages consumed is essential for comparing studies and understanding the characteristics of the dietary patterns.

- Many of the studies were conducted with predominantly Caucasian adults. Additional research should be conducted to examine if and how race/ethnicity, age, and sex might influence the relationship between dietary patterns and health outcomes.

Additionally, more research is recommended to:

- Advance dietary pattern methodologies to better elucidate the indispensable components, or the “drivers,” of dietary patterns that are instrumental in promoting health and preventing disease.
- Investigate other aspects of dietary patterns, including where and when foods and beverages are consumed.
- Test the effectiveness of dietary patterns identified in observational studies in randomized controlled trials.
- Examine the effects of different methods by which components are chosen, grouped, and scored and the effect those different methods have on the resulting relationships with health outcomes, regarding *a priori* scores.
- Evaluate and standardize methods used to assess, organize, aggregate, and adjust food variables to facilitate interpretation of findings across studies, regarding *a posteriori* approaches.