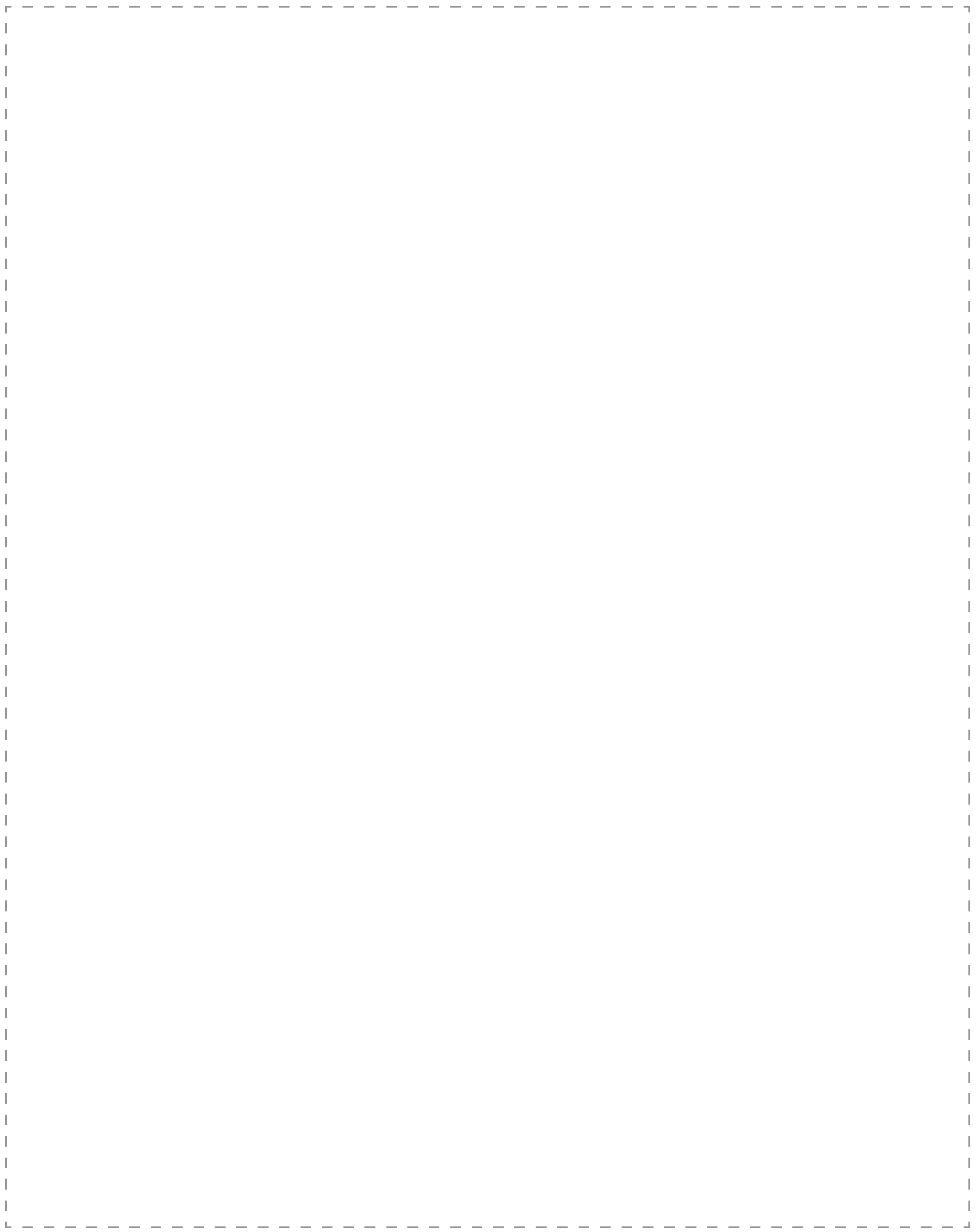




PART 1

# APPLYING NUTRITION IN PUBLIC HEALTH

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# APPLYING NUTRITION SCIENCE TO THE PUBLIC'S HEALTH

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*If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have found the safest way to health.—Hippocrates 460–377 BCE*

## LEARNING OBJECTIVES

After studying this chapter and reflecting on the contents, you should be able to:

1. Explain how and why nutrition policies, programs, and practice must be evidence based.
2. Evaluate the peer-reviewed literature and assess bodies of evidence used to form nutrition policies and recommendations.
3. Compare and contrast different types of research studies and explain how they are used to form policies, programs, and consumer information.
4. Explain how and why nutrition policies, recommendations, and programs are changed at regular intervals.
5. Use the same resources as public health nutritionists to keep pace with current research or available programs that are grounded in research.

## KEY TERMS

Center for Nutrition Policy and Promotion

Cohort study

Cross-sectional study

Dietary Guidelines for Americans (DGA)

Dietary Reference Intakes (DRI)

Evidence-based practice

Healthy Eating Index (HEI)

*Healthy People 2020*

Hierarchy of evidence

National Health and Nutrition Examination Survey (NHANES)

MyPlate, MyWins

National Nutrition Monitoring and Related Research Program (NNMRRP)

Nutrition monitoring

Peer-reviewed literature

PubMed

Public health nutritionist

Randomized controlled trials

## INTRODUCTION

Hippocrates was right, but for the rest of us, appreciation of this relationship was a long time in coming. Prior to the 1970s, public health nutrition was focused primarily on feeding programs and preventing nutrient deficiency diseases. Early in the 20th century, there was a general lack of understanding of the relationship between diet and disease, and diseases such as pellagra and rickets were common. As food availability improved and the prevalence of deficiency diseases decreased, there was a growing awareness that dietary excess and imbalance increased the risk of developing chronic disease, such as coronary heart disease (CHD), hypertension, type 2 diabetes mellitus, and cancer.<sup>1</sup>

In 1977, the U.S. Senate Select Committee on Nutrition and Human Needs, under the leadership of Senator George McGovern, issued *Dietary Goals for the U.S.*<sup>2</sup> The goals engendered controversy among health professionals and the food industry because of the way they were conceived and presented. At that time, there was also a lack of consensus on the impact of food/nutrients on chronic disease risk. In retrospect, the authors of these dietary goals were remarkably perspicuous. The statement by Dr. C. Edith Weir, Assistant Director of the Human Nutrition Research Division, U.S. Department of Agriculture (USDA), that “Most all of the health problems underlying the leading causes of death in the U.S. could be modified by improvements in diet”<sup>2</sup> remains the cornerstone of public health nutrition and nutrition policy in the United States.

Today, the preponderance of epidemiologic, clinical, and laboratory data have clearly linked both diet and physical inactivity with chronic disease. Four of the leading causes of death—heart disease, cancer, cerebrovascular disease, and diabetes mellitus—are related directly to poor diet, physical inactivity, and other lifestyle factors.<sup>3</sup> The cost of these diseases to the United States, both in terms of direct patient care and lost productivity, is staggering; for example, in 2010 heart disease and stroke cost approximately \$315.4 billion with \$193.4 billion in direct patient care.<sup>4</sup> Cancer care in 2010 cost \$157 billion and, in 2012 undiagnosed diabetes mellitus cost \$245 billion with \$176 billion going to direct medical costs.<sup>4</sup> More information about the cost of chronic diseases at the state level can be found through the chronic disease cost calculator.<sup>5</sup>

Not included among the four major causes of death, but a major contributor to these and other health problems, is obesity. Obesity has reached epidemic proportions. **National Health and Nutrition Examination Survey (NHANES)** data from 2011 to 2014<sup>6</sup> showed that among adults 34.3% of males and 38.3% of females were obese

or had a body mass index (BMI) >30.<sup>7</sup> The prevalence of obesity among U.S. children 2–19 years of age was 17.0% in 2011–2014. The prevalence of obesity among children 2–5 years of age (8.9%) was lower than among children 6–11 years (17.5%) and adolescents 12–19 years (20.5%). The same pattern was seen in males and females.<sup>6</sup> Obesity is calculated differently in children than in adults because the relationship between BMI and body fat in children varies with age and pubertal maturation; thus, a single cutoff cannot be used for all ages. For children, a percentile range on the Centers for Disease Control and Prevention (CDC) growth charts is used: less than the 5th percentile is underweight, the 5th to <85th percentile is normal weight, 85th to <95th percentile is considered obese, and >95th percentile is considered obese.<sup>8</sup>

A significant increase in obesity in adults and children was seen from 1999–2000 through 2013–2014; however, no change was seen in children between 2003–2004 and 2013–2014. No significant change in obesity prevalence among adults or children was seen between 2011–2012 and 2013–2014.<sup>6</sup> In the United States, the current estimated healthcare costs of obesity range from \$147 billion to nearly \$210 billion. This does not include the nearly \$4.3 billion associated with job absenteeism and lower productivity at work.<sup>9,10</sup> Obesity has surpassed tobacco, alcohol, and poverty as a public health risk.<sup>11,12</sup> Thus, it is crucial to work toward reducing disease risk and promoting healthy behaviors in all individuals.

These health problems are not unique to the United States. Globally, largely preventable chronic diseases account for 60% of all deaths (35 million people), 80% of whom live in low- or middle-income countries.<sup>13</sup> Over the next decade, it is estimated that more than 75% of deaths worldwide will result from these diseases, with 60% occurring in developing countries that are experiencing rapid health transitions. The World Health Organization (WHO)<sup>14</sup> has compared the spread of chronic diseases to that of communicable diseases; however, chronic diseases appear to be “spread” by the Westernization of diets and the decline in physical activity associated with increasing industrialization rather than by infectious or parasitic agents. The WHO finalized a global strategy to improve diet and increase physical activity to reduce the risk of chronic noncommunicable diseases while continuing to carry forward the long-term WHO goals on other nutrition-related areas, including undernutrition.

Relatively few modifiable risk factors—for example, a lack of fruit and vegetables in the diet, obesity, smoking, inappropriate use of alcohol, and physical inactivity—cause the majority of the chronic disease burden. Changes in diet and physical activity patterns can significantly reduce

disease risk, often in a surprisingly short time period. It has been estimated that a 1% reduction in intake of fat and saturated fatty acids and a 0.1% reduction in intake of cholesterol would, over 20 years, prevent more than 56,000 cases of Coronary Heart Disease (CHD)<sup>15</sup> and more than 18,000 deaths; these changes would also save more than 117,000 life-years. Improved dietary patterns could save more than \$43 billion in medical care costs and lost productivity resulting from CHD, cancer, stroke, and diabetes and prevent more than 119,900 premature deaths among individuals 55 to 74 years of age. As the average life expectancy in the United States continues to rise, and if current dietary and physical activity patterns remain unchanged, the incidence and prevalence of chronic diseases will continue to increase.

## PUBLIC HEALTH NUTRITION AND PUBLIC HEALTH NUTRITIONISTS

The Institute of Medicine's (now known as the Health and Medicine Division of the National Academies of Sciences, Engineering, and Medicine) *The Future of the Public's Health in the 21st Century* states that the mission of public health is "to assure conditions where people can be healthy."<sup>16</sup> This report extends the *Future of Public Health* report, which asserted that public health is "what we as a society do collectively to assure the conditions in which people can be healthy."<sup>17</sup> **Public health nutritionists** or registered dietitians working in public health settings can play decisive roles in improving our nation's health.<sup>16,17</sup> Challenges for health professionals in the 21st century include shifting demographics, changes in eating and physical activity patterns, disparities in health care, and global economic pressures.

Public health nutritionists need to be able to understand what drives food and physical activity choices by the public. Food choices are driven by taste; convenience; accessibility, availability, and affordability of foods; ethnic or religious preferences; socioeconomic status; health and nutrition knowledge; shopping practices; and time.<sup>18–26</sup> The decision not to engage in regular physical activity may be driven by lack of knowledge and attitudes about physical activity recommendations, lack of a safe place to exercise or of social support, lack of access to programs, and time.<sup>27–30</sup>

Without knowing why different populations choose healthy foods or choose not to exercise, it is difficult to understand why people eat what they do, why they do or do not engage in physical activity, or why they are or

are not able to plan interventions and design policies and recommendations that change behavior that will lead to a healthier lifestyle.

Public health nutritionists need to have a broad grasp of the sciences, including the pathophysiology of disease, genetics, and biotechnology and its impact on sustainable agriculture, nutrition biochemistry and molecular biology, nutrigenomics, informatics, biostatistics, epidemiology, and, of course, nutrition sciences. Finally, public health nutritionists need to know what information and resources are available to them to help plan and assess programs at the national, state, local, or individual levels.

Today, for consumers and health professionals alike, there is a bewildering array of diet and physical promotion information available on the Internet and through other media channels.<sup>31,32</sup> A 2009 survey of more than 1,000 adults conducted by the American Dietetic Association (now the Academy of Nutrition and Dietetics) showed that nearly 80% were interested in finding nutrition information on the Internet, and 70% visited two or three websites when using the Internet to find food and nutrition information. Virtually all participants believed the information they found online was reliable and trustworthy.<sup>33</sup> It is vital that health professionals, including registered dietitians, provide timely, accurate on line information,<sup>34</sup> help consumers understand that not all information available is accurate, and help them understand how to distinguish sound science. To do this, we as health professionals need to understand how to evaluate information.

In this chapter, we look at examples of how to interpret and evaluate the professional literature to (1) make evidence-based practice decisions in public health; (2) learn the science behind nutrition recommendations, policy, and legislation; and (3) find ways for nutritional science to be translated into messages for consumers.

## PEER-REVIEWED LITERATURE AND EVIDENCE-BASED PRACTICE

**Peer-reviewed literature** is the *gold standard* for scientific information provided to the public as well as the information used for setting recommendations and policies, designing and evaluating nutrition programs, and conducting ethical evidence-based nutrition and dietetics practice. Unfortunately, the literature can be difficult to understand, and results from different studies can be contradictory. Use of different study designs, populations, or methods—including statistical analyses—contribute to the confusion.

Assessing the science behind the policies, programs, practice, and consumer information begins with asking a question and finding, reading, and evaluating the articles needed to answer it. **PubMed** is the premiere database for articles on nutrition topics. This database contains more than 19 million citations for biomedical articles from MEDLINE and life science journals. Many citations in PubMed include links to full-text articles from PubMed Central or publisher websites. Important databases for nutrition-related research are shown in **Table 1–1**.

After asking a question and determining the appropriate database to use, the next stage is selecting the descriptors and

conducting the search. The descriptors and the search limits depend on the question(s) you are asking. For example, if your question is, “What is the effect of 100% fruit juice consumption on weight in children?” your descriptors could be “fruit juice” OR “fruit” AND “weight” OR “BMI” AND “children” OR “adolescents.” The search might be easier if your search limit is “All Children,” then the last two descriptors could be eliminated.

Scanning the titles and abstracts will allow you to determine which articles are appropriate for answering your question. Obtaining the full-text articles, either by downloading them or visiting the library, and assessing

**Table 1–1 Databases Important for Nutritional Sciences Literature Searches**

Database	Purpose
AGRICOLA	Provides citations in agriculture and related fields.
AGRIS	International information system for the agricultural sciences and technology; created by the Food and Agriculture Organization of the United Nations (FAO).
BRFSS Behavioral Risk Factor Surveillance System: Survey Data	Includes eight databases on specific illnesses or aspects of chronic disease prevention and health promotion; designed to help public health professionals and educators locate program information.
CARIS Current Agricultural Research Information System	Created by FAO to identify and to facilitate the exchange of information about current agricultural research projects being carried out by or on behalf of developing countries.
The Cochrane Library	Contains reliable evidence from Cochrane and other systematic reviews, clinical trials, and more. Cochrane reviews bring you the combined results of the world’s best medical research studies and are recognized as the gold standard in evidence-based health care.
Directory of Open Access Journals	This database increases the visibility and ease of use of open access journals and promotes their increased usage and impact.
EMBASE	The most comprehensive course for answers on biomedical answers.
ERIC Educational Resources Information Center	Includes educational research and resources; early childhood education, junior colleges and higher education; reading and communications skills; languages and linguistics; education management; counseling and personnel services; library and information science; information resources.
Food Safety Research Database	The Food Safety Research Information Office is located at the National Agricultural Library. This office provides information on publicly funded, and to the extent possible, privately funded food safety research initiatives to prevent unintended duplication of food safety research and to assist the executive and legislative branches of the government and private research entities in assessing food safety research needs and priorities.
FSTA Food Science and Technology Abstracts	The largest collection of food science, food technology, and food-related human nutrition abstracts. It contains more than 580,000 records with approximately 2,000 new records added every month. FSTA covers journal articles (~80%) plus patents, theses, standards, legislation, books, reviews, and conference proceedings.
Health Source: Nursing/Academic Edition	Provides approximately 600 scholarly full-text journals, including nearly 450 peer-reviewed journals focusing on many medical disciplines. Also features abstracts and indexing for nearly 850 journals.



**Table 1–1 Databases Important for Nutritional Sciences Literature Searches (continued)**

Database	Purpose
Index to Scientific and Technical Proceedings	Indexes the published literature of the most significant conferences, symposia, seminars, colloquia, workshops, and conventions in a wide range of disciplines in science and technology over the last 5 years.
LILACS Latin American and Caribbean of Health Sciences Information System	Includes bibliographic control and dissemination of health scientific-technique literature from Latin American and Caribbean countries, absent from other the international databases.
MEDLINE	Sponsored by the National Library of Medicine, contains citations and abstracts to international biomedical literature from more than 3,700 journals on topics including research, clinical practice, administration, policy issues, and healthcare services.
Merck Index Online	A one-volume encyclopedia of chemicals, drugs, and biologicals that contains more than 10,000 monographs, 32 supplemental tables, and 450 Organic Name Reactions. Entries cover drugs and pharmaceuticals, describe common organic chemicals and laboratory reagents, cover naturally occurring substances and plants, the elements and on inorganic chemicals, and compounds of agricultural significance.
Nursing and Allied Health Source	Provides reliable healthcare information covering nursing, allied health, alternative and complementary medicine, and related topics.
Science Citation Index	This database covers the journal literature of the sciences.
Science Direct	A Web information source for scientific, technical, and medical research. It offers access to more than 1,100 journals in 16 fields of science, including the social sciences.
Scopus™	The largest abstract and citation base of peer-reviewed literature.
Web of Science	Indexes more than 5,800 major journals across 164 scientific disciplines.

If your library does not have access to these databases, just ask the librarian at your university to help you.

them are the next steps (**Table 1–2**). This is not a casual reading to prepare a summary of the article but a critical evaluation of the published study—try it out with a subject of interested to you. However, a single peer-reviewed article is not sufficient for making ethical **evidence-based practice** decisions; setting public health goals (e.g., *Healthy People 2020*); developing dietary recommendations (e.g., **Dietary Reference Intakes [DRI]**); mandating nutrition policy (e.g., **Dietary Guidelines for Americans [DGA]**); or designing nutrition programs for health professionals and the public (e.g., the Produce for Better Health Foundation’s Fruits and Veggies More Matters”). To do this, the strength of a body of scientific studies must be assessed.<sup>35, 36</sup>

The Agency for Healthcare Research and Quality, through its Evidence-Based Practice Centers, sponsors the development of evidence reports and technology assessments to assist public and private sector organizations in their efforts to improve the quality of health care in the United States.<sup>37</sup> Three important domains should be addressed to grade the strength of the evidence: (1) the

quality of the studies—including the extent to which bias was minimized, (2) the quantity of the studies—including the magnitude of effect, the number of studies conducted, and the sample size or power of the studies, and (3) the consistency of results—whether similar studies produce similar results.

Another critical consideration when assessing the body of evidence is the study design: what type of study was used to produce the test results, and what was the relevance to the disease/condition/program under study? Some study designs are more powerful than others in providing evidence on a topic; this has given rise to the concept of a **hierarchy of evidence**<sup>38</sup> about the effectiveness of interventions, treatments, practice protocols, or policies. From bottom (least convincing) to top (best evidence) the hierarchy is generally presented as expert opinion, case reports, case series, case-control studies; **cross-sectional studies**; **cohort studies** (prospective or retrospective); **randomized controlled trials (RCT)**; and systematic reviews of RCT with or without meta-analysis. It should be kept in mind,

**Table 1–2 How to Assess an Article from the Peer-Reviewed Literature**

<p><i>Title</i></p> <ol style="list-style-type: none"> <li>1. Did the title reflect what was actually done in the study? The purpose, the populations used, the findings, and conclusions can be reflected in the title. A positive statement about the contents, rather than a title that is a question, is preferred.</li> </ol> <p><i>Abstract</i></p> <ol style="list-style-type: none"> <li>1. Did the abstract clearly outline all aspects of the manuscript?             <ol style="list-style-type: none"> <li>a. The purpose of the study</li> <li>b. The methods</li> <li>c. The results</li> <li>d. The conclusions</li> </ol> </li> <li>2. Was enough information provided to understand what was done and what was found?</li> </ol> <p><i>Introduction</i></p> <ol style="list-style-type: none"> <li>1. Did the authors provide enough background information to understand why the study was done?</li> <li>2. Did the authors provide enough background information to let you know what others have done on this topic and where there might be gaps in the literature?*</li> <li>3. Were important studies omitted from the introduction? This might suggest bias.</li> <li>4. Did the authors clearly state the purpose of the study? A hypothesis or research question should have been stated. Not all study designs are appropriate for testing hypotheses; for example, cross-sectional studies are hypothesis generating.</li> </ol> <p><i>Materials and Methods (could be phrased Subjects and Methods)</i></p> <ol style="list-style-type: none"> <li>1. Was the type of study clearly defined?</li> <li>2. Did the experimental design allow the research question or hypotheses to be tested?</li> <li>3. If appropriate, was a control group included? Was it comparable to the test group?</li> <li>4. Was the population appropriate for the study?</li> <li>5. Was the population suitable to generalize results?</li> <li>6. Was the population well defined?             <ol style="list-style-type: none"> <li>a. Number/adequate sample size for appropriate statistical power.</li> <li>b. Gender, age, race/ethnicity, income, etc.</li> <li>c. Inclusion/exclusion criteria for the study.</li> <li>d. If the study population was a subset of a larger population, was it clear how the study population differed from the larger population? This could indicate bias.</li> <li>e. Was a convenience sample used or were the participants randomized?</li> </ol> </li> <li>7. Were there ethical concerns if human subjects or vertebrate animals were used? Was there a clear statement that the research had been approved by the appropriate committee?</li> <li>8. Were the methods presented in enough detail so that the research could be repeated (or built upon) by another research team?</li> <li>9. Were the methods used reliable and valid?</li> <li>10. Statistical methods:             <ol style="list-style-type: none"> <li>a. Were they appropriate?</li> <li>b. Were outcome variables clearly defined?</li> <li>c. Did the authors control for potential confounding variables?</li> <li>d. Was a statistical probability level clearly stated?</li> </ol> </li> <li>11. Was it clearly stated how the data will be presented in the results (e.g., data are presented as mean <math>\pm</math> standard error [SE])?</li> <li>12. Were all terms defined?</li> </ol> <p><i>Results</i></p> <p>This section should present study results only. No methodology should be presented unless it is a combined Results and Discussion section; there should be no interpretation of the information.</p> <ol style="list-style-type: none"> <li>1. Were results organized in a logical sequence?             <ol style="list-style-type: none"> <li>a. Did the results follow the same order as the methods?</li> </ol> </li> <li>2. Were demographics presented?</li> <li>3. Were the graphics appropriate?             <ol style="list-style-type: none"> <li>a. Were they needed? Should more/less be included?</li> <li>b. Was the information clearly presented in labeled tables and figures? Can the tables and figures stand alone?</li> <li>c. From a biological standpoint were the data reasonable?</li> </ol> </li> </ol>
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**Table 1–2 How to Assess an Article from the Peer-Reviewed Literature (continued)***Discussion*

1. Were the study objectives met?
2. Did the authors adequately interpret their results?
3. Did the authors discuss their results and compare them with the current literature?
4. Was the discussion related directly to the results or was it overly speculative?
5. If nonstandard methods were used, were they adequately discussed?
6. Were limitations of the study clearly stated?
7. Were conclusions drawn? Were they supported by the results?

*References*

1. Were appropriate citations listed? Were they accurate? Were they timely?
2. Were enough references presented so that a cogent whole presentation was in the manuscript?

*Acknowledgments*

1. Were the funding sources clearly identified?
2. Were there real or apparent conflicts of interest, which could suggest bias?

\*This is difficult for those unfamiliar with the literature but becomes easier with practice and familiarity with the topic.

however, that this hierarchy assumes that all studies were well designed and executed. A poor RCT may not provide the same level of evidence as a very well-designed cross-sectional study.

To assess a body of evidence, many organizations, including the National Heart, Lung, and Blood Institute (NHLBI), the Academy of Nutrition and Dietetics, and

the American Diabetes Association, have grading scales. The NHLBI uses a four-point scale to grade the scientific evidence from different study types (**Table 1–3**). The Evidence Analysis Library (EAL) of the Academy uses a five-step process, the fourth of which is to summarize evidence and the last is to develop a conclusion statement and assign a grade.

**Table 1–3 National Heart, Lung, and Blood Institute’s Evidence Categories**

Category	Sources of Evidence	Definition
Category A	Randomized controlled trials (rich body of data)	Well-designed, randomized clinical trials that provide a consistent pattern of findings in the population for which the recommendation is made. Category A requires substantial numbers of studies involving substantial numbers of participants.
Category B	Randomized controlled trials (limited body of data)	Limited randomized trials or interventions, post-hoc subgroup analyses, or meta-analyses of randomized clinical trials. These are used when there are a limited number of existing trials, study populations are small or provide inconsistent results, or when the trials were undertaken in a population that differs from the target population of recommendation.
Category C	Observational or nonrandomized studies	Evidence is from outcomes of uncontrolled or nonrandomized trials or from observational studies.
Category D	Panel Consensus Judgment	Expert judgment is based on the panel’s synthesis of evidence from experimental research described in the literature or derived from the consensus of panel members based on clinical experience or knowledge that does not meet the above criteria. This category is used only where the provision of some guidance was deemed valuable but an adequately compelling clinical literature addressing the subject of the recommendation was deemed insufficient to place it in one of the other categories.

Reproduced from: U.S. Department of Health and Human Services, The Obesity Education Initiative. (1998). *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults, The Evidence Report* (NIH Pub. No. 98-4083), table ES-1. [http://www.nhlbi.nih.gov/guidelines/obesity/ob\\_gdlns.pdf](http://www.nhlbi.nih.gov/guidelines/obesity/ob_gdlns.pdf).

For the academy's EAL, the scoring system is somewhat different. "The Academy uses Grades I, II, III, IV, and V for strong, fair, weak, expert opinion only, and no evidence, respectively." Examples of evidence statements for a wide variety of nutrition-related topics are found on the EAL's website, including, but not limited to Adult Weight Management, Bariatric Surgery, Fruit Juice, Heart Failure, Hypertension, and Sodium. Caveats that should be considered for all types of evidence reviews are that they are time-consuming and new studies are continually being published. Be sure you use the most recent information available in your evidence review and in your practice.

In addition to the EAL, the USDA's Nutrition Evidence Library (NEL) conducts systematic reviews to inform nutrition policy and programs, including the Dietary Guidelines for Americans. The process that the EAL and NEL use to evaluate a body of literature on a given topic is similar. The process used by the NEL is to "recruit expert workgroup, formulate evidence analysis questions, conduct literature review for each question, extract evidence and critically appraise each study, synthesize the evidence, and develop and grade a conclusion statement."

## NUTRITION MONITORING

Collecting nutrition and health-related information from a population is critical for designing and evaluating policies and programs that improve health status and decrease risk factors. Scientists analyze data from **nutrition monitoring** programs and use these analyses to contribute to the literature. To be useful, information must be collected in a timely manner and presented to scientists, policy makers, and the public in a readily understandable form. Without current monitoring, decisions may be made using insufficient information or incorrect assumptions. Nutrition and health-related information can be obtained using several methods, notably through nutrition screening, assessment, and surveillance; these are often collectively referred to as nutrition monitoring.

*Nutrition screening* is a systematic approach to quickly identify nutrition problems or individuals at nutritional risk who are in need of further assessment or an intervention. Screening can be done in free-living and hospitalized individuals; however, it is important to use validated instruments to maximize the chance of correctly identifying at risk individuals.<sup>39,40</sup> The Mini Nutritional Assessment, used in screening elderly populations,<sup>41</sup> is a widely used valid screening instrument. Many other screening tools are available for nutrition professionals, including, but not

limited to, those designed to determine malnutrition,<sup>42</sup> diabetes risk,<sup>43</sup> and food security.<sup>44</sup>

*Nutrition assessment* measures indicators of dietary status, using methods such as 24-hour diet recalls, food frequency questionnaires (FFQ), food diaries, or newer dietary assessment methods including digital photography<sup>45-49</sup> or use of mobile phones to keep food records.<sup>50</sup> Principal strengths of 24-hour diet recalls are that they provide detailed information about the types and amounts of food consumed on a given day, have a low response burden, and are cost-effective.<sup>45</sup> The principal limitations are that they are memory-dependent, respondents may under- or overreport consumption, and 24-hour diet recalls should not be used to assess individual diets. Collection of group data from 24-hour diet recalls with mean reporting, for example, as used by What We Eat in America, the dietary component of the NHANES, is an appropriate use of 24-hour diet recalls<sup>45</sup>; however, it has long been recognized that 24-hour diet recalls may not reflect usual intake.<sup>51,52</sup> In 2003, staff members of NHANES began collecting two recalls, the first in person in the Mobile Examination Center and the second 3 to 10 days later by telephone. The National Cancer Institute, coupled with the **Center for Nutrition Policy and Promotion (CNPP)**, developed a statistical method to calculate usual intake using both recalls.<sup>53-56</sup> Multiple 24-hour dietary recalls using the multiple pass method<sup>45</sup> is the standard for assessing intake (**Table 1-4**). Because intake may change on weekend days, it is important to include both weekday and weekend days in the recalls.

It should be noted that NHANES also collects information on supplement and prescription medication intake, food security, some consumer behaviors, and anthropometrics. These data can be used with the data collected from the recalls not only to further the nutrition assessment but also to look for associations among variables.

Food frequency questionnaires vary in the number of food items, food groups, and food portion assessments—all of which affect nutrient intake.<sup>57,58</sup> Similar to 24-hour diet recalls, FFQs often underestimate intake of total energy,<sup>59,60</sup> and energy adjustment can be used to reduce the effects of measurement error, that is, regression dilution.<sup>61,62</sup> It is also important that appropriate racial and ethnic foods consumed by the population of interest be included when designing FFQs. Although a wide variety of FFQs are in use, some have not been validated against 24-hour recalls or direct observation. Using meta-analyses, FFQs with longer food lists (200 items) were shown to have 0.01 to 0.17 higher correlation coefficients than FFQs with shorter food lists (100 items) for most nutrients.<sup>63</sup> An advantage of FFQs

**Table 1–4 Information Collected During National Health and Nutrition Examination Survey Diet Interviews**

5-Step Multiple-Pass Approach		For each food and beverage consumed during previous 24-hour period	Detailed description
Step	Purpose		
<b>Quick List</b>	Collect a list of foods and beverages consumed the previous day.		Additions to the food
↓			Amount consumed
<b>Forgotten Foods</b>	Probe for foods forgotten during the Quick List.		What foods were eaten in combination
↓			Time eating occasion began
<b>Time &amp; Occasion</b>	Collect time and eating occasion for each food.		Name of eating occasion
↓			Food source (where obtained)
<b>Detail Cycle</b>	For each food, collect detailed description, amount, and additions. Review 24-hour day.		Whether food was eaten at home
↓		Amounts of food energy and 60+ nutrients/food components provided by the amount of food (calculated)	
<b>Final Probe</b>	Final probe for anything else consumed.	For each respondent on each day	Day of the week
			Amount and type of water consumed, including total plain water, tap water, and plain carbonated water
			Source of tap water
			Daily intake usual, much more or much less than usual
			Use and type of salt at table and in preparation
			Whether on a special diet and type of diet
			Frequency of fish and shellfish consumption (past 30 days)
		Daily total intakes of food energy and 60+ nutrients/food components (calculated)	

Reproduced from: NHANES Dietary Web: Dietary Data Overview. Task 2: Key Concepts About NHANES Dietary Data Collection. Tutorial. <http://www.cdc.gov/nchs/tutorials/dietary/surveyorientation/dietarydataoverview/info2.htm>.

is that they can be self-administered and thus are suitable for large epidemiologic studies.

Digital photography to determine food intake,<sup>47–49</sup> including by individuals with their own cell phones,<sup>50</sup> is also used. These technology methods are appealing, but accuracy is dependent on training staff, study participants, or clients to take consistent photographs. Other methods used to determine intake include direct observation, plate waste, and food records with or without the weighing of foods.

Accurate determination of intake is critical. Intake of food groups can be determined using instruments as conventional as the MyPlateSuperTracker,<sup>64</sup> which is appropriate for the public, and the Food Patterns

Equivalents Database,<sup>65</sup> which may be more appropriate for health professionals. Nutrient intake can be assessed using the USDA National Nutrient Database for Standard Reference,<sup>66</sup> the Food and Nutrient Database for Dietary Studies,<sup>67</sup> and commercially available diet analysis programs. These databases may not all yield the same nutrient analyses, and it is best to be consistent when using them to analyze data. Whenever possible, dietary intake should be confirmed using appropriate biomarkers; for example, folate intake should be confirmed with serum folate levels.<sup>68,69</sup> Intake of nutrients or food groups can be compared with recommended values for specific populations and, in turn, with the prevalence or incidence of chronic disease.

*Surveillance* comes from the French verb *surveiller*, “to watch over.” In 1968, the World Health Assembly described surveillance as “the systematic collection and use of epidemiologic information for planning, implementation, and assessment of disease control.”<sup>70</sup> Surveillance, in contrast to surveys, is continuous, and data that are collected can be used to provide the framework for public health policies and the rationale for intervention. Surveillance also provides a way to monitor the effectiveness of specific interventions. This completes the loop—surveillance studies that can be used to determine nutritional problems or nutritional needs. After the intervention, they can be used to determine whether the problems remain or the intervention was effective.

Most governments track the health and nutrition status of their population. For example, the U.S. government has tracked information on food and the food supply for more than 100 years, starting with the USDA’s Food Supply Series in 1909. The first USDA Household Food Consumption Survey (known as the Nationwide Food Consumption Survey after 1965) was begun in the 1930s. In 1960, the National Health Examination Survey was initiated; however, it did not include information on nutrition and its link with diet. Thus, federal officials could not provide information on diet and disease or undernutrition to Congress. The nation’s first comprehensive nutrition survey was the Ten-State Nutrition Survey conducted between 1968 and 1970 in 10 states: California, Kentucky, Louisiana, Massachusetts, Michigan, New York, South Carolina, Texas, Washington, and West Virginia. The NHANES I and II and the Pediatric Nutrition Surveillance Systems were initiated in the 1970s.

In 1990, the **National Nutrition Monitoring and Related Research Program (NNMRRP)** (PL 101-445) established a comprehensive, coordinated program for nutrition monitoring and related research to improve health and nutrition assessment in U.S. populations. The NNMRRP required a program to coordinate federal nutrition monitoring efforts and to assist state and local governments in participating in a nutrition monitoring network; an interagency board to develop and implement the program; and a nine-member advisory council to provide scientific and technical advice and to evaluate program effectiveness. The NNMRRP also required that the Dietary Guidelines for Americans (DGA) be issued every 5 years, and that any dietary guidance issued by the federal government for the general public be reviewed by the secretaries of Agriculture and Health and Human Services (HHS).

The NNMRRP encompasses more than 50 surveillance activities that monitor and assess health and

nutritional status in the United States. Monitoring efforts are divided into five overarching areas: nutrition and related health measurements; food and nutrient consumption; knowledge, attitude, and behavior assessments; food composition and nutrient databases; and food supply determinants. Important monitoring programs are summarized in **Table 1–5**. Most of the data sets generated through this program are available to the public. Some are restricted, due to confidentiality or disclosure rules/regulations, but can be accessed by researchers through application to the Research Data Center in the National Center for Health Statistics (NCHS) headquarters in Hyattsville, Maryland.

## Goals of NHANES

- Estimate the number and percent of persons in the U.S. population, and designated subgroups, with selected diseases and risk factors.
- Monitor trends in the prevalence, awareness, treatment, and control of selected diseases.
- Monitor trends in risk behaviors and environmental exposures.
- Analyze risk factors for selected diseases.
- Study the relationship between diet, nutrition, and health.
- Explore emerging public health issues and new technologies.
- Establish a national probability sample of genetic material for future genetic research.
- Establish and maintain a national probability sample of baseline information on health and nutritional status.

In 2002, the Department of HHS and the USDA integrated NHANES and the Continuing Survey of Food Intakes by Individuals (CSFII), the two major diet and health surveys, into a continuous data collection system. Now diet and nutrition information can be linked directly to health status information. The integrated dietary component of the NHANES is titled, “*What We Eat in America*.”<sup>71</sup>

The NHANES is a program of studies designed to assess the health and nutritional status of the U.S. population. The survey combines health interviews and physical examinations with dietary information (**Table 1–6**).

Beginning in 1999, the NHANES survey became a continuous surveillance program with data released to the public biannually. Rather than using a random sample, the NHANES uses a complex, multistage, probability sampling design to select participants representative of the civilian, noninstitutionalized U.S. population. Oversampling of population subgroups at different times (e.g., Hispanic

**Table 1–5 National Nutrition-Related Health Assessments<sup>a</sup>**

Survey Name	Date	Target	Data Collected	Dept/Agency
<b>Nutritional and Related Health Measurements</b>				
NHANES <sup>b</sup>	1999–present	Civilian, noninstitutionalized persons 2 months or older; oversampling of adolescents, African Americans, Mexican Americans, and adults >60 years	Survey elements are similar to NHANES III and NHIS. <sup>c</sup> This is a continuous monitoring system	NCHS, CDC (HHS)
NHANES III	1988–1994	Civilian, noninstitutionalized persons 2 months or older; oversampling of adolescents, non-Hispanic blacks, Mexican Americans, children 6 years and adults >60 years	Demographics, dietary intake (24-hour recall and food frequency), biochemical analysis of blood and urine, physical examination, anthropometry, blood pressure, bone densitometry, diet and health behaviors, health conditions	NCHS, CDC (HHS)
NHANES III Supplemental Nutrition Survey of Older Persons	1988–1994	Representative U.S. elderly population	See above	NCHS, NIH/NIA
HHANES	1982–1984	Civilian, noninstitutionalized Mexican Americans in five southwestern states, Cuban Americans in Dade Co., FL, and Puerto Ricans in New York, New Jersey, and Connecticut, 6 months to 74 years	Demographics, dietary intake (24-hour recall and food frequency), biochemical analysis of blood and urine, physical exam, anthropometry, blood pressure, diet and health behaviors, health conditions	NCHS (HHS)
NHANES II	1976–1980	Civilian, noninstitutionalized persons 6 months to 74 years	Demographics, dietary intake, biochemical analysis of blood and urine, physical exam, anthropometry	NCHS (HHS)
NHANES I	1971–1974	Civilian, noninstitutionalized population of the conterminous states 1 to 74 years	Demographics, dietary information, biochemical analysis of blood and urine, physical exam, anthropometry	NCHS (HHS)
PedNSS	1973, continuous	Low-income, high-risk children, birth to 17 years, emphasis on birth to 5 years	Demographics, anthropometry, birth weight, hematology	NCCDPHP, CDC (HHS)
PNSS	1973, continuous	Convenience sample of low-income, high-risk pregnant women	Demographics, pregravid weight and maternal weight gain, anemia, behavioral risk factors, birth weight, and formula-feeding data	NCCDPHP, CDC (HHS)

*(continues)*

**Table 1–5 National Nutrition-Related Health Assessments<sup>a</sup> (continued)**

Survey Name	Date	Target	Data Collected	Dept/Agency
<b>Food and Nutrient Consumption</b>				
CSFII <sup>d</sup>	1994–1996; 1989–1991; 1985–1986	Individuals of all ages with oversampling in low-income households	One- and 3-day food intakes, times of eating events, sources of food eaten away from home	ARS, HNIS
TDS	1961, annual	Specific age and gender groups	Determines levels of nutrients and contaminants in the food supply; analyses are performed on foods that are “table-ready”	FDA (HHS)
Consumer Expenditure Survey	1980, continuous	Noninstitutionalized population and a portion of the institutionalized population in the United States	Demographics, food stamp use, average annual food expenditures	U.S. Bureau of Labor Statistics
NFCS	1987; 1977–1978	Households in the conterminous states; all income and low income	Households: quantity (pounds), money value (dollars), and nutritive value of food eaten Individuals: food intake, times of eating events, and sources of foods eaten away from home	HNIS (USDA); ARS (USDA)
SNDA II	1998	Public schools in the 48 contiguous states and the District of Columbia that participate in the National School Lunch Program	School and food service characteristics, nutrients by food group and relationship to the RDA and DGA by meals, source of meals, and nutrient content of USDA meals	FNS/USDA
WIC Feeding Practices Study	1994–1995	Pre- and postnatal women and their children who participate in Women, Infants, and Children (WIC) program	Demographics, rates of breast and formula feeding, factors associated with breast feeding	FNS/USDA
5-A-Day for Better Health Baseline Survey	1991	Adults 18 years and older	Demographics, fruit and vegetable intake, and knowledge, attitudes, and practices regarding intake	NCI (HHS)
<b>Knowledge, Attitude, and Behavior Assessments</b>				
YRBBS	Biennial	Civilian, noninstitutionalized adolescents 12–18 years	Demographics, diet and weight; drug, alcohol and tobacco use; seat belt and bicycle helmet use; behaviors that contribute to violence; suicidal tendencies <sup>e</sup>	CDC; (HHS)/NCCDPHP



Table 1–5 National Nutrition-Related Health Assessments<sup>a</sup> (continued)

Survey Name	Date	Target	Data Collected	Dept/Agency
BRFSS	1984, continuous	Adults 18 years and older in households with telephones located in participating states	Demographics, questions that assess risk factors associated with leading causes of death: alcohol and tobacco use, weight, seat belt and helmet use; use of preventative medical care <sup>f</sup>	CDC; (HHS)/NCCDPHP
DHKS	1994–1996	Adults 20 years and older who participated in CSFII 1994–1996	Demographics, self-perceptions of relative intake, awareness of diet and health relationships, food label use, perceived importance of following diet and health recommendations, beliefs about food safety, and knowledge of sources of nutrients; data can be linked with intake through CSFII data	ARS/USDA
Infant Feeding Practices Survey	1993–1994	New mothers and healthy infants to 1 year of age	Demographics, prior infant feeding practices, baby's social situation, characteristics associated with breast feeding, development of allergies	FDA
Consumer Food Handling Practices	1998; 1992–1993	Civilian, noninstitutionalized over 18 years with telephones	Demographics, prevalence of unsafe food handling practices, knowledge of food safety principles, use of sources of information about safe food handling, incidence of food borne illnesses	FDA
<b>Food Composition and Nutrient Data Bases</b>				
National Nutrient Data Bank	–	–	This is the repository for values of approximately 7,100 foods and up to 80 components. Essentially all food composition databases are derived from this data bank	ARS (USDA)
Food Label and Package Survey	1977–1996, biennially	All brands of processed foods regulated by the FDA	Prevalence of nutrition labeling, declaration of select nutrients, prevalence of label claims and other descriptors	FDA (HHS)

(continues)

**Table 1–5 National Nutrition-Related Health Assessments<sup>a</sup> (continued)**

Survey Name	Date	Target	Data Collected	Dept/Agency
<b>Food Supply Determinations</b>				
AC Nielsen SCANTRACK	1985, monthly	~3,000 U.S. supermarkets	Sales and physical volume of specific market items, selling price, percent of stores selling the product	ERS/USDA
U.S. Food and Nutrient Supply Series	1909, annually	U.S. population	ERS = Amount of food commodities that disappear into the food distribution system; CNPP = nutrient levels of food supply. Results are totaled for each nutrient and converted to per day basis	ERS/CNPP/USDA

<sup>a</sup>A complete guide to nutrition monitoring in the United States can be found at <http://www.cdc.gov/nchs/data/misc/nutri98.pdf>.

<sup>b</sup>Abbreviations: ARS = Agricultural Research Service; BRFSS = Behavioral Risk Factor Surveillance System; CDC = Centers for Disease Control and Prevention; CNPP = Center for Nutrition Policy and Promotion; CSFII = Continuing Survey of Food Intakes by Individuals; DHKS = Diet and Health Knowledge Survey; ERS = Economic Research Service; FDA = Food and Drug Administration; HHANES = Hispanic Health and Nutrition Examination Survey; HHS = Health and Human Services; HNIS = Human Nutrition Information Service; NFCS = Nationwide Food Consumption Survey; NCCDPHP = National Center for Chronic Disease Prevention and Health Promotion; NCHS = National Center for Health Statistics; NCI = National Cancer Institute; NHANES = National Health and Nutrition Examination Survey; NHIS = National Health Interview Survey; NIA = National Institute on Aging; NIH = National Institutes of Health; PedNSS = Pediatric Nutrition Surveillance System; PNSS = Pregnancy Nutrition Surveillance System; SNDA = School Nutrition Dietary Assessment Study; TDS = Total Diet Study; USDA = United States Department of Agriculture; WIC = Women, Infants, and Children; YRBSS = Youth Risk Behavioral Surveillance System.

<sup>c</sup>See [http://www.cdc.gov/nchs/data/nhanes/survey\\_content\\_99\\_16.pdf](http://www.cdc.gov/nchs/data/nhanes/survey_content_99_16.pdf) for complete survey content of NHANES 1999–2016.

<sup>d</sup>CSFII and NHANES were combined into a single survey.

<sup>e</sup>See <http://www.cdc.gov/mmwr/PDF/SS/SS5302.pdf> = YBRSS report 2004; *MMWR* summary reports available through CDC website.

<sup>f</sup>See [http://www.cdc.gov/brfss/#about\\_BRFSS](http://www.cdc.gov/brfss/#about_BRFSS) = Behavioral Risk Factor Surveillance System for full information.

Americans) increases the reliability and precision of health status indicator estimates for these subgroups. Data collection by the NHANES occurs at three levels: a brief household screener interview, an in-depth household survey interview, and a medical examination. Because detailed interviews and clinical, laboratory, and radiological examinations are conducted, the response burden to participants is significant. Interviews and medical examinations take place in a mobile examination center. Because of this sampling design, using appropriate statistical analyses of NHANES data are critical. To ensure that NHANES analyses reflect a nationally representative sample, it is important to use the described weighting system and specialty software (e.g., SUDAAN).

It is difficult to quantify the tremendous impact that NHANES and related programs have had on health policy and health research in the United States.<sup>72</sup> One way to look at this is the number of publications generated using NHANES data. A PubMed search in April 2016 using

the term “NHANES” produced 35,089 publications on topics as diverse as national trends in self-reported physical activity/sedentary behavior in pregnant women; trends in cardiovascular risk and trends in obesity; BMI in children and adolescents; and the association of consumption of 100% fruit juice and nutrient intake in children. NHANES data have also shown that there are ethnic/racial and income differences in dietary intake, including food sources for nutrients;<sup>73–75</sup> that cardiovascular risk factors cluster according to socioeconomic status;<sup>76</sup> and that hypertension varies according to geographical region.<sup>77</sup> These findings have important implications for intervention strategies.

## EPIDEMIOLOGIC STUDIES

In addition to the NCHS data, a number of long-term, primarily government funded epidemiologic studies on adults and children/adolescents have provided critical

**Table 1–6 Data Available Through NHANES****Health Exam Tests***Health Measurements by Participant Age and Gender*

- Physician's exam: all ages
- Blood pressure: ages  $\geq 8$  years
- Bone density: ages  $\geq 8$  years
- Condition of teeth: ages  $\geq 5$  years
- Vision test: ages  $\geq 12$  years
- Hearing test: ages 12–19 and  $\geq 70$  years
- Height, weight, and other body measures: all ages
- Ophthalmology exam for eye diseases: ages  $\geq 40$  years
- Breathing tests: ages 6–79 years

**Lab Tests on Urine ( $\geq 6$  years)**

- Kidney function tests: ages  $\geq 6$  years
- Sexually transmitted disease (STD), chlamydia and gonorrhea: ages 14–39 years
- Exposure to environmental chemicals: selected persons ages  $\geq 6$  years
- Pregnancy test: girls and women ages  $\geq 12$  years, and girls ages 8–11 years who have periods

**Lab Tests on Blood: ( $\geq 1$  year and older)**

- Anemia: all ages
- Total cholesterol and high density lipoprotein (HDL): ages  $\geq 6$  years
- Glucose measures: ages  $\geq 12$  years
- Infectious diseases: ages  $\geq 2$  years
- Kidney function tests: ages  $\geq 12$  years
- Lead: ages  $\geq 1$  years
- Cadmium: ages  $\geq 1$  year
- Mercury: ages  $\geq 1$  year
- Liver function tests: ages  $\geq 12$  years
- Nutrition status: ages  $\geq 1$  years
- Thyroid function test: ages  $\geq 12$  years
- Prostate specific antigen (PSA): men ages  $\geq 40$  years
- Sexually transmitted diseases (STD)
  - Genital herpes: ages 14–49 years
  - Human immunodeficiency virus (HIV): ages 18–49 years
  - Human papillomavirus (HPV) antibody: ages 14–59 years
- Exposure to environmental chemicals: selected persons ages  $\geq 6$  years

**Lab Tests on Water**

- Environmental chemicals: ages  $\geq 12$  years in half of households

**Other Lab Tests**

- Vaginal swabs (self-administered): girls and women ages 14–59 years
- Human papillomavirus (HPV): ages 14–59 years

**Private Health Interviews**

- Health status: ages  $\geq 12$  years
- Questions about drug and alcohol use: ages  $\geq 12$  years (no drug testing will be done)
- Reproductive health: girls and women ages  $\geq 12$  years
- Questions about sexual experience: ages 14–69 years
- Tobacco use: ages  $\geq 12$  years

**Anthropometry from the Mobile Examination Center**

- Body mass index for children ages 2–19 years; BMI z-score is also determined
- Waist circumference
- Skinfold measurements and body fat measures through DXA

**Dietary Information from the Mobile Examination Center**

- 24-hour dietary recalls; parents or guardians report for children 0–5 years of age; children 6–11 years are assisted by an adult; children  $\geq 12$  years self-report
- Food frequency questionnaire

*(continues)*

**Table 1–6 Data Available Through NHANES (continued)****After the Visit to the NHANES Examination Center**

- Persons asked about the foods they eat will receive a phone call 3–10 days after their exam for a similar interview, all ages.
- Then participants, or an adult for participants 1–15 years old, are asked about food shopping habits.
- Persons who test positive for hepatitis C will be asked to participate in a brief telephone interview 6 months after the exam. Parents will respond for children.

information used to guide the nation's health policies and federal programs. The Bogalusa Heart Study (BHS), the Framingham Heart Study (FHS), and the Coronary Artery Risk Development in Young Adults (CARDIA) are leading examples. Other important U.S. epidemiologic studies that have contributed to our knowledge of risk reduction and disease prevention include the Nurses' Health Study (NHS;  $N = 170,000$  women registered nurses between the ages of 30 and 55 years at the beginning of the study) and the NHS II (NHS II established in 1989,  $N = \sim 117,000$  women nurses aged between 25 and 42 years); and the all-men Health Professional Follow-up Study (initiated in 1986 with 2-year scheduled follow-ups), which was designed to complement the NHS, relating nutritional factors to the incidence of serious illnesses, such as cancer, heart disease, and other vascular diseases in 51,529 male health professionals. Also of import is the Iowa Women's Health Study with a cohort of 41,837 postmenopausal women who have been followed since 1985. These studies combined have produced more than 2,000 scientific publications and have helped shape medical care, risk reduction and health promotion, and public policy.

## THE BOGALUSA HEART STUDY

The BHS<sup>78–80</sup> was designed initially to examine the early natural history of coronary heart disease and essential hypertension in a biracial (black/white) pediatric population. The BHS population consists of approximately 5,000 individuals who have been studied at various growth phases and have been followed for as long as 15 years. The mixed epidemiologic design of the study has included cross-sectional and longitudinal surveys to provide information on three questions: (1) what are the distribution and prevalence of cardiovascular disease (CVD) risk factors in a defined pediatric population and how are abnormal serum lipid levels, blood pressure, and other risk factors defined in children; (2) do cardiovascular risk factors track and change over time; and (3) what is the interrelationship among these risk factors? Other questions, notably what is the interaction of genetics and the environment in CVD, were also posed.

Data from the BHS have contributed significantly to our knowledge and understanding of cardiovascular risk factors in children as well as the history of CVD in early life. For example, information on children, adolescents, and young adults from birth to 31 years of age has provided the framework to establish desirable cholesterol levels in children and has led investigators to recommend screening of cardiovascular risk factors for all children, not only those with a parental history of heart disease or dyslipidemia, beginning at elementary school age.

Data have also suggested that risk factors for CVD “track”; that is, they remain in a rank relative to peers over time. For example, children with elevated serum total cholesterol or low density lipoprotein cholesterol (LDL-C) levels are likely to become adults with dyslipidemia. Bogalusa Heart Study data have been used to characterize diets of children and secular trends in children's diets for more than 30 years.<sup>81</sup> BHS data were used as the rationale by the American Academy of Pediatrics for their recommendation that the DGA could apply to healthy children 2 years of age and older, and to develop the Academy's original position paper on dietary guidance for healthy children 2 to 11 years of age.<sup>82</sup>

One of the major accomplishments of the BHS did not come from epidemiologic data per se, but from autopsy studies of participants,<sup>83</sup> usually those killed in accidents. Data from the BHS confirmed and extended earlier studies<sup>84</sup> that showed fatty streaks in the aorta were evident in the first decade of life and that the extensiveness of these lesions was highly associated with serum total cholesterol and LDL-C levels. These findings provided the rationale for interventions that focused on healthy lifestyles for children.

## FRAMINGHAM HEART STUDY

The FHS has been described as “one of the most impressive medical works in the 20th century.”<sup>85</sup> The Framingham study has provided information critical to the recognition and management of atherosclerosis, and its causes and complications. Initiated under the auspices of the National Heart Institute (now the NHLBI) in 1948, 1,980 males and 2,421 females were enrolled originally in a 3-year

observational study in Framingham, Massachusetts, which at the time was a novel idea. Published in 1961, the first report, “Factors of risk in the development of coronary heart disease—six-year follow-up experience; the Framingham Study,” identified high blood pressure, smoking, and high cholesterol levels as major factors in heart disease and conceptualized them as risk factors. Continued study of the population has provided health professionals with multifactorial risk profiles for cardiovascular disease that have assisted in identifying individuals at high risk as well as providing the basis for preventative measures. During its more than 50 year history, the FHS has introduced the concept of biologic, environmental, and behavioral risk factors; identified major risk factors associated with heart disease, stroke, and other diseases; revolutionized preventive medicine; and changed how the medical community and general population regard disease pathogenesis. The National Cholesterol Education Program<sup>15</sup> uses the Framingham risk scoring system to determine the 10-year risk of CHD in adults. Studies like the Framingham study have also supplied valuable information to the Eighth Report of the Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.<sup>86</sup>

In 1971, the Framingham Heart Offspring Study began,<sup>87</sup> consisting of 5,124 males and females, 5 to 70 years of age, who were offspring and spouses of the offspring of the original Framingham cohort. The objectives of that study were to determine the incidence and prevalence of CVD and its risk factors, trends in CVD incidence and its risk factors over time, and family patterns of CVD and risk factors. The Offspring Study provided the opportunity to evaluate a second generation of participants, assess new or emerging risk factors and outcomes, and provide a resource for future genetic analyses.

The quality of data from surveys and epidemiologic studies depends on the training of personnel and adherence to rigid protocols. It also depends on the validity and reliability of the test instruments used as well as on the responses of the participants. Instruments may need to be modified for specific populations. For example, in the BHS the 24-hour diet recall method had to be adapted for use in children.<sup>88,89</sup> To improve the reliability and validity of the 24-hour diet recall, quality controls included the use of a standardized protocol that specified exact techniques for interviewing, recording, and calculating results; standardized graduated food models to quantify foods and beverages consumed; a product identification notebook for probing of snack consumption, and foods and beverages most commonly forgotten; school lunch assessment to identify all school lunch recipes, preparation methods, and average portion

sizes of menu items reflected in each 24-hour diet recall; follow-up telephone calls to parents to obtain information on brand names, recipes, and preparation methods of meals served at home; products researched in the field to obtain updated information on ingredients and preparation, and their weights (primarily snack foods and fast foods).<sup>90</sup> All interviewers participated in rigorous training sessions and pilot studies before the field surveys to minimize interviewer effects. One 24-hour diet recall was collected on each study participant, and duplicate recalls were collected from a 10% random subsample to assess interviewer variability.<sup>88,89</sup>

## METABOLIC DIET STUDIES

Metabolic diet studies are conducted in clinical research centers where study participants are randomized into test or control groups and are fed an experimental diet or “regular” diet, respectively. Different designs are available for metabolic diet studies,<sup>91</sup> but the one that provides the most valid results is a double-blind, placebo-controlled study. In these studies, neither the investigator nor the participant knows whether the test or control diet is offered. Because it is difficult and expensive to do these studies, they are usually short term and have a small sample size; compliance and dropout rates are problems.

The Dietary Approaches to Stop Hypertension (DASH)<sup>92</sup> and DASH sodium<sup>93</sup> trials are classic examples of metabolic diet studies. Epidemiologic, clinical trials, and studies using experimental animals showed that intake of some nutrients, notably low levels of sodium and high levels of potassium and calcium, lowered blood pressure; however, people eat food—not isolated nutrients. To test the impact that combination diets incorporating foods high in these nutrients had on blood pressure, the DASH study was conducted. DASH was a randomized controlled trial conducted at four academic medical centers with 459 adult participants. Inclusion criteria were untreated systolic blood pressure less than 160 mm Hg and diastolic blood pressure 80 to 95 mm Hg. For 3 weeks, participants ate a control diet. They were then randomized to 8 weeks of a control diet; a diet rich in fruits and vegetables; or a combination diet rich in fruits, vegetables, and low-fat dairy foods, and low in saturated fatty acids, total fat, and cholesterol. Salt intake and weight were held constant, and diets were isoenergetic. All food was prepared in a metabolic kitchen and was provided to participants. The combination diet (or “DASH diet”) was shown too quickly (within 2 weeks) and substantially lower blood pressure. In DASH sodium, a subsequent study, 412 participants were assigned to a control diet or a DASH diet; within the assigned diet,



participants ate meals with high (3,450 mg/2,100 kcals), intermediate (2,300 mg/2,100 kcals) and low (1,150 mg/2,100 kcals) levels of sodium for 30 consecutive days each, in random order. Reduction of sodium intake to levels below the current recommendation of 100 mmol/day and the DASH diet substantially lowered blood pressure, with the most significant effect seen in lowering blood pressure with the lowest sodium concentration coupled with the DASH diet. The DASH diet has been widely embraced for the treatment of hypertension, and nutrition education materials are readily available. As elegant and persuasive as the DASH studies were, one drawback to feeding studies is that participants receive all foods. Therefore, the studies cannot assess how compliant people are after the study ends. The PREMIER study<sup>94</sup> demonstrated that free-living individuals were able to make the lifestyle changes associated with decreased blood pressure.

## CLINICAL TRIALS

Clinical trials are commonly used to determine the efficacy of drugs or other pharmacologic agents; however, they can also be used to assess diet or dietary interventions. They have many of the same advantages and disadvantages of metabolic studies. Because clinical trials of diet may involve pharmacologic intervention, they carry a risk that is not usually seen with metabolic diet studies. The classical example of this was seen in the Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study (ATBC Study)<sup>95</sup> and the Beta-Carotene and Retinol Efficacy Trial (CARET).<sup>96</sup> Based on epidemiologic data that showed a relationship between dietary intake of fruits and vegetables<sup>97,98</sup> or, specifically, of beta carotene<sup>99</sup> and a reduced risk of developing lung cancer, especially in smokers,<sup>100</sup> the ATBC and CARET studies used high doses of beta-carotene in major cancer chemopreventive trials. Investigators expected to see reductions in lung cancer by as much as 49% in some high-risk groups. In actuality, the opposite was seen; beta-carotene increased the risk of lung cancer, forcing the CARET study to be stopped early.<sup>101</sup> These studies clearly point to the necessity of additional research, and they have important public health implications.

## ANIMAL STUDIES

Animal studies are important in nutrition research for many reasons. Laboratory animals that are genetically identical and exposed to the same environmental conditions can be fed carefully characterized diets with different combinations

of nutrients; thus, the number of variables studied is limited. Special treatments, such as ovariectomies to mimic the physiologic state of postmenopausal women,<sup>102</sup> can be performed on animals. Because the life span of most laboratory animals is short, the effects of dietary manipulation can be followed over several generations. Animals can be sacrificed at the end of the experiment and the effect of the treatment can be examined closely at the organ, tissue, or cellular level. Animal studies can explore molecular mechanisms behind a given observation in humans. For example, ferrets were used to determine that high doses of beta-carotene caused keratinized squamous metaplasia in lung tissues that was exacerbated by exposure to cigarette smoke.<sup>103</sup> This explains the paradoxical relationship between beta-carotene and smoking seen in the clinical trials previously mentioned. It points out another use of animal studies: that the metabolism of natural products should be investigated using animal models *before* beginning intervention trials, particularly if nutrient doses exceed recommended levels.<sup>104</sup>

Animals most commonly used in nutrition research are rats, mice, rabbits, guinea pigs, dogs, sheep, and monkeys. The species selected for a given experiment should be that which is the most similar to human metabolism for a particular nutrient. The importance of this is illustrated in the classic studies of vitamin C metabolism. Guinea pigs are the only laboratory animal that, like humans, have an obligatory requirement for this nutrient; thus, a review of the literature shows only guinea pigs were used for vitamin C research.

Many of the elements that make animal studies so appealing in nutrition research are also drawbacks. With the exception of monozygotic twins, humans are not genetically identical; thus, no matter how carefully a human experiment is controlled, responses to dietary manipulations may be different due to individual genetic backgrounds. Interactions between genetics and the environment are easy to study in animals, but results are difficult to translate to humans.

## HEALTHY PEOPLE 2020

Individual health is closely linked to community health—the health of the community and the environment in which individuals live, work, and play. Community health, in turn, is profoundly affected by the collective beliefs, attitudes, and behaviors of everyone who lives in that community. *Healthy People 2020*, published by the Department of Health and Human Services (HHS),<sup>105</sup> is the comprehensive health promotion and disease prevention agenda for the nation; the goals for HP 2020 will remain in



place until superseded by HP 2030. The HP program grew out of health initiatives pursued over the last 30 years. In 1979, *Healthy People: The Surgeon General's Report on Health Promotion and Disease Prevention*<sup>106</sup> provided nutritional goals for reducing premature deaths and preserving independence for older adults. In 1980, *Promoting Health/Preventing Disease: Objectives for the Nation* targeted 226 health objectives for the nation to achieve over the next 10-year period.<sup>107</sup> These were followed by HP 2000, 2010, and, now 2020 goals.

The overarching goals for HP 2020 are:<sup>105</sup>

- Attain high-quality, longer lives free of preventable disease, disability, injury, and premature death;
- Achieve health equity, eliminate disparities, and improve the health of all groups;
- Create social and physical environments that promote good health for all; and
- Promote quality of life, healthy development, and healthy behaviors across all life stages.

*Healthy People 2020* has 42 topic areas and tracks approximately 1,200 objectives. *Healthy People 2020* also has 12 Leading Health Indicators (**Table 1–7**); **Table 1–8** shows the principal objectives associated with HP 2020's Nutrition and Weight Topics. Many of the nutrition objectives are similar to those of the DGA.

The NCHS is responsible for coordinating efforts to monitor progress toward the HP objectives. Data are gathered from approximately 200 sources, including the NCHS data systems<sup>108</sup> and other federal government data systems. State data are also provided for selected indicators, and additional resources are found in the Health Indicators Warehouse.<sup>109</sup> Data from HP 2020 can be explored using the DATA2020 section of the HP 2020 website.<sup>110</sup>

Many states have developed their own HP plans.<sup>111</sup> Development of state-specific plans allows states to prioritize health problems, address needs of specific racial or

ethnic groups, and develop solutions that are economically feasible for state budgets. States and territories have a Healthy People Coordinator who serves as a liaison with the Office of Disease Prevention and Health Promotion. Check out the Office of Public Health in your own state and see what the problems relating to public health are and what's being done about them. For example, I just found out about the Partners for Healthy Babies program in my home state of Louisiana.<sup>112</sup>

## NUTRIENT REQUIREMENTS

The first Recommended Daily Allowances (RDAs) were published in 1941 “as a guide for advising on nutrition problems in connection with national defense.”<sup>113</sup> The first edition included recommendations for only nine nutrients: protein, thiamine, riboflavin, niacin, ascorbic acid, vitamins A and D, calcium, and iron. In the seventh edition (1968), additional nutrients were included: folate; vitamins E, B<sub>6</sub>, and B<sub>12</sub>; phosphorous; magnesium; and iodine. The last edition of the RDAs (1989) added vitamin K, zinc, and selenium. The RDAs should be geared to groups of healthy people, such as the military or school feeding programs, rather than to individuals. The RDAs are, however, often used to assess the adequacy of an individual's diet and were later called the Recommended Dietary Allowances.

In 1993, the question of whether the RDAs should be changed was posed by the National Academies of Sciences, Engineering, and Medicine's Health and Medicine Division (HMD) (formerly the Institute of Medicine's [IOM] Food and Nutrition Board [FNB]). Support for change included that (1) sufficient new scientific information had accumulated to substantiate (reassessment of these recommendations; (2) sufficient data for efficacy and safety existed, and reduction in the risk of chronic diet-related diseases needed to be considered—previously, the RDA had focused on preventing deficiency diseases; (3) upper levels of intake should be established where there were data concerning risk of adverse effects; and (4) components of food not meeting the traditional concept of a nutrient—such as phytochemicals—that gave possible health benefits should be reviewed, and if adequate data existed, reference intakes should be established.

Between 1994 and 2004, the Food and Nutrition Board DRI (Dietary Reference Intake) extended and replaced the former RDAs and the Canadian Recommended Nutrient Intakes.<sup>114</sup> The DRIs are available on the website of the Food and Nutrition Information Center of the National Agricultural Library.<sup>114</sup> The DRIs are specified on age, gender, and life stage (e.g., pregnancy or lactation), and

**Table 1–7 Leading Health Indicators of Healthy People 2020**

Access to health services  
 Clinical preventive services  
 Environmental quality  
 Injury and violence  
 Maternal, infant, and child health  
 Mental health  
 Nutrition, physical activity, and obesity  
 Oral health  
 Reproductive and sexual health  
 Social determinants  
 Substance abuse  
 Tobacco

**Table 1–8 Principal Objectives Associated with *Healthy People 2020's* Nutrition and Weight Topics**

Healthier food access	NWS-1 Increase the number of states with nutrition standards for foods and beverages provided to preschool-aged children in child care NWS-2 Increase the proportion of schools that offer nutritious foods and beverages outside of school meals NWS-3 Increase the number of states that have state-level policies that incentivize food retail outlets to provide foods that are encouraged by the Dietary Guidelines for Americans NWS-4 (Developmental) Increase the proportion of Americans who have access to a food retail outlet that sells a variety of foods that are encouraged by the Dietary Guidelines for Americans
Health care and worksite settings	NWS-5 Increase the proportion of primary care physicians who regularly measure the body mass index of their patients NWS-6 Increase the proportion of physician office visits that include counseling or education related to nutrition or weight NWS-7 (Developmental) Increase the proportion of worksites that offer nutrition or weight management classes or counseling
Weight status	NWS-8 Increase the proportion of adults who are at a healthy weight NWS-9 Reduce the proportion of adults who are obese NWS-10 Reduce the proportion of children and adolescents who are considered obese NSW-11 (Developmental) Prevent inappropriate weight gain in youth and adults
Food insecurity	NSW-12 Eliminate very low food security among children NSW-13 Reduce household food insecurity and in doing so reduce hunger
Food and nutrient consumption	NSW-14 Increase the contribution of fruits to the diets of the population aged 2 years and older NSW-15 Increase the variety and contribution of vegetables to the diets of the population aged 2 years and older NSW-16 Increase the contribution of whole grains to the diets of the population aged 2 years and older NSW-17 Reduce consumption of calories from solid fats and added sugars in the population aged 2 years and older NWS-18 Reduce consumption of saturated fat in the population aged 2 years and older NWS-19 Reduce consumption of sodium in the population aged 2 years and older NWS-20 Increase consumption of calcium in the population aged 2 years and older
Iron deficiency	NWS-21 Reduce iron deficiency among children and females of childbearing age NWS-22 Reduce iron deficiency among pregnant females

Reproduced from: Office of Disease Prevention and Health Promotion. *Healthy People 2020: Nutrition and Weight Status*. <https://www.healthypeople.gov/2020/topics-objectives/topic/nutrition-and-weight-status/objectives>. Accessed April 11, 2016.

cover more than 40 nutrient substances. Conceptually, the DRIs are the same as the RDAs in that their formulation relies on the best scientific evidence available at the time of issuance, are designed for healthy individuals over time, and can vary depending on life cycle stage or gender. The reference values for heights and weights of adults and children used in the DRIs are from NHANES III. The DRIs differ from the original RDAs in that they incorporate the concepts of disease prevention, upper levels of intake and potential toxicity, and nontraditional nutrients. The latter establishes a precedent; as scientists learn more about the relationship of phytochemicals, herbals, or botanicals and health, these too can be incorporated into the recommendations. Where scientific evidence is available, the DRIs are a set of at least four nutrient-based reference

values. Briefly, the four reference values are the estimated average requirement (EAR), RDA, tolerable upper intake level (UL), and adequate intake (AI). The EAR is the median usual intake value estimated to meet the requirements of half of the healthy individuals; it is based on specific criteria of adequacy and on careful review of the scientific evidence. Not all nutrients have an EAR because there may not be an acceptable science base upon which to define one. The EAR is used to calculate the RDA ( $RDA = EAR + 2$  standard deviation of the requirement), which is the average daily dietary intake level sufficient to meet the nutrient requirement of approximately 98% of individuals. If there is no EAR for a nutrient, there can be no RDA. If this is the case, an AI for the nutrient is provided. This value is deemed by experts to meet or to exceed the needs of a

healthy population. The AI can be used as a guide for intake, but it cannot be used for all the applications for which the EAR is used; it is also an indication that additional research is required for a nutrient. The assumption is that when this research is completed and evaluated, the AI can be replaced by an EAR and RDA. The UL is the highest level of continued daily nutrient intake that is unlikely to pose an adverse health effect. (It is important to note that the word “tolerable” was chosen to avoid implying a possible beneficial effect.)

The HMD has published DRIs and related information for electrolytes and water;<sup>115</sup> energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids;<sup>116</sup> vitamins A and K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc;<sup>117</sup> dietary antioxidants and other related compounds;<sup>118</sup> folate and other B vitamins;<sup>119</sup> calcium, phosphorus, magnesium, vitamin D, and fluoride;<sup>120</sup> and an updated volume on vitamin D and calcium.<sup>121</sup> A complete set of the DRI books is available online or can be ordered in book form or read online.

Important uses of the DRIs include individual diet planning, dietary guidance, institutional food planning, military food and meal planning, planning for food assistance programs, food labeling and fortification, developing new or modified food products, and guaranteeing food safety. In planning menus/diets for individuals or groups, it is important to meet the RDA or AI without exceeding the UL. The HMD has incorporated the DRIs and other data into a series of reports, including School Meals: Building Blocks for Healthy Children,<sup>122</sup> Local Government Actions to Prevent Childhood Obesity,<sup>123</sup> the Public Effects of Food Deserts<sup>124</sup> (Workshop Summary), Nutrition Standards and Meal Requirements for National School Lunch and Breakfast Programs: Phase I. Proposed Approach for Recommending Revisions,<sup>125</sup> and the Use of Dietary Supplements by Military Personnel.<sup>126</sup> Summaries of the development of the DRI<sup>127</sup> as well as the uses of the DRI in dietary assessment<sup>128, 129</sup> and to plan menus<sup>130</sup> can be found in the literature.

## CENTER FOR NUTRITION POLICY AND PROMOTION

The Center for Nutrition Policy and Promotion (CNPP), created in December 1994, is an office of the USDA’s Food, Nutrition, and Consumer Services. Its mission is “to improve the health of Americans by developing and promoting dietary guidance that links scientific research to

the nutrition needs of consumers.”<sup>131</sup> The CNPP carries out its mission to improve the health of Americans by (1) advancing and promoting food and nutrition guidance for all Americans; (2) assessing diet quality; and (3) advancing consumer, nutrition, and food economic knowledge.

The major projects of the CNPP are shown in **Table 1–9**. The CNPP considers MyPlate/MiPlato and SuperTracker as tools; other tools include Food-a-Pedia, What’s Cooking? USDA Mixing Bowl, and the Cost of Raising a Child Calculator.

## DIETARY GUIDELINES FOR AMERICANS

The DGA<sup>132</sup> are the foundation of federal nutrition policy, nutrition education programs, and information activities. The DGA are evidence-based recommendations for food (and some nutrient intake) designed to promote health and reduce the risk of chronic disease for healthy Americans 2 years of age and older. By law (Public Law [PL] 101-445), the DGA are developed and published jointly by the departments of HHS and USDA every 5 years. This relatively quick turnaround time is a result of the changing science as new studies are added to the evidence base. The eighth edition of the DGA (2015–2020) was released in January 2016 (earlier editions were published in 1980, 1985, 1990, 1995, 2000, 2005, and 2010). The 2015–2020 DGA will remain in effect until the 2020–2025 DGA are released. Changes in the DGA must reflect current scientific and medical knowledge available at the time of publication. Two important documents demonstrate the necessity of relying on a science base: the 1988 *Surgeon General’s Report on Nutrition and Health*<sup>133</sup> and 1989 *National*

**Table 1–9 Projects of the Center for Nutrition Policy and Promotion**

Dietary Guidelines for Americans	Know Your Farmer, Know Your Food
MyPlate, MyWins/MiPlato	Nutrient Content of the U.S.
SuperTracker	Food Supply
Healthy Eating Index	Birth to 24 Months and Pregnant Women
USDA Food Patterns	Nutrition Insights
USDA Food Plans: Cost of Food	Internship Program
Expenditures on Children by Families	Health and Medicine Division Study
USDA’s Nutrition Evidence Library	Archived Projects

*Research Council's Report, Diet and Health: Implications for Reducing Chronic Disease Risk.*<sup>1</sup>

The DGA appear as succinct statements of nutrition recommendations for the general public, as seen in **Table 1–10** and **Table 1–11**. However, the discussion of the evidence and the initial recommendations are made by the Dietary Guidelines Advisory Committee. Take a moment and learn about the process of how the DGA are developed. The website<sup>132</sup> for the DGA provides a considerable number of tools that can be used by health professionals, including registered dietitians:

- **Talk to Your Patients & Clients About Healthy Eating Patterns** [PDF, 1.6 MB] includes nutrition tips and conversation starters for dietitians, nurses, and other providers working with the public.
- **Shift to Healthier Food & Beverage Choices (Handout for Patients or Clients)** [PDF, 1.5 MB] offers a closer look at a central DGA concept.
- **Cut Down on Added Sugars (Handout for Patients or Clients)** [PDF, 1.9 MB] offers a how-to guide for reducing added sugars.
- **DGA Presentation for Professionals** [PPTX, 28.3 MB] [PDF, 3.8 MB] has information and

graphics about the 2015–2020 Dietary Guidelines. Download the PowerPoint slide deck to customize the presentation or the PDF to use it as is.

- **2015–2020 DGA: Questions and Answers about the DGA and how it was developed.**

**MyPlate, MyWins** is the “translation” of the DGA for the public,<sup>135</sup> although it too has information available for nutrition professionals.<sup>136</sup> This information includes Nutrition Communicators Network, Communicator's Guide, Teachers, Health Professionals, and MyPlate Graphic Resources.

The DGA dictates U.S. federal nutrition policies and programs, which directly affect nearly 45 million Americans receiving electronic benefits from the Supplemental Nutrition Assistance Program (SNAP);<sup>137</sup> 30.5 million children participating in the National School Lunch Program;<sup>138</sup> nearly 10 million women, infants, and children receiving benefits under the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program;<sup>139</sup> and more than 3 million adults over 60 years of age through the Elderly Nutrition Program.<sup>140</sup> The DGA also affects information policy, as evidenced in MyPlate, food labels, and federal nutrition education programs, such as the SNAP-education program. This program includes toolkits such as the *SNAP-Ed Strategies & Interventions: An Obesity Prevention Toolkit for States*, which provides evidence-based policy, systems, and environmental changes that support direct educational social marketing and ways to evaluate them across various settings. The reliance on and the consistency of following the DGA ensure that nutrition information promulgated by the government is the same for all federal programs. Although not mandated, the DGA also provide the foundation for nutrition recommendations and programs from nonfederal agencies such as the American Heart Association and the American Cancer Society.

**Table 1–10 The 2015–2020 Dietary Guidelines for Americans<sup>132</sup>**

**Follow a healthy eating pattern across the life span.** All food and beverage choices matter. Choose a healthy eating pattern at an appropriate calorie level to help achieve and maintain a healthy body weight, support nutrient adequacy, and reduce the risk of chronic disease.

**Focus on variety, nutrient density, and amount.** To meet nutrient needs within calorie limits, choose a variety of nutrient-dense foods across and within all food groups in recommended amounts.

**Limit calories from added sugars and saturated fats and reduce sodium intake.** Consume an eating pattern low in added sugars, saturated fats, and sodium. Cut back on foods and beverages higher in these components to amounts that fit within healthy eating patterns.

**Shift to healthier food and beverage choices.** Choose nutrient-dense foods and beverages across and within all food groups in place of less healthy choices. Consider cultural and personal preferences to make these shifts easier to accomplish and maintain.

**Support healthy eating patterns for all.** Everyone has a role in helping to create and support healthy eating patterns in multiple settings nationwide, from home to school to work to communities.

## MYPLATE, MYWINS

In the United States, food group plans have provided dietary guidance based on current scientific knowledge for almost 100 years. The USDA published its first recommendations in 1916. Between 1916 and the 1940s, plans had between 5 and 16 separate food groups and were published by various government agencies. In 1943, as part of the wartime effort, the USDA published the *National Wartime Nutrition Guide*. The *Basic Seven Food Guide*, derived from the *Wartime Guide*, was issued and was used until 1955 when the Department of Nutrition at the Harvard School

**Table 1–11 Key Recommendations that Support the Five Dietary Guidelines<sup>132</sup>**

Consume a healthy eating pattern that accounts for all foods and beverages within an appropriate calorie level.

A healthy eating pattern includes:

- A variety of vegetables from all of the subgroups—dark green, red and orange, legumes (beans and peas), starchy, and other
- Fruits, especially whole fruits
- Grains, at least half of which are whole grains
- Fat-free or low-fat dairy, including milk, yogurt, cheese, and/or fortified soy beverages
- A variety of protein foods, including seafood, lean meats and poultry, eggs, legumes (beans and peas), and nuts, seeds, and soy products
- Oils

A healthy eating pattern limits:

- Saturated fats and trans fats, added sugars, and sodium

Key recommendations that are quantitative are provided for several components of the diet that should be limited. These components are of particular public health concern in the United States, and the specified limits can help individuals achieve health eating patterns within calorie limits:

- Consume less than 10% of calories per day from added sugars
- Consume less than 10% of calories per day from saturated fats
- Consume less than 2,300 milligrams (mg) per day of sodium
- If alcohol is consumed, it should be consumed in moderation—up to one drink per day for women and up to two drinks per day for men—and only by adults of legal drinking age

In tandem with these recommendations, Americans of all ages—children, adolescents, adults, and older adults—should meet the Physical Activity Guidelines for Americans to help promote health and reduce the risk of chronic disease. Americans should aim to achieve and maintain a healthy body weight. The relationship between diet and physical activity contributes to calorie balance and managing body weight. As such, the Dietary Guidelines includes a key recommendation to

- Meet the Physical Activity Guidelines for Americans<sup>134†</sup>

For substantial health benefits, do one of the following:

- 150 minutes (2 hours and 30 minutes) each week of moderate-intensity aerobic physical activity (such as brisk walking or tennis)
- 75 minutes (1 hour and 15 minutes) each week of vigorous-intensity aerobic physical activity (such as jogging or swimming laps)
- An equivalent combination of moderate- and vigorous-intensity aerobic physical activity

For adults 65 years of age and older, do aerobic activity.

For substantial health benefits, do one of the following:

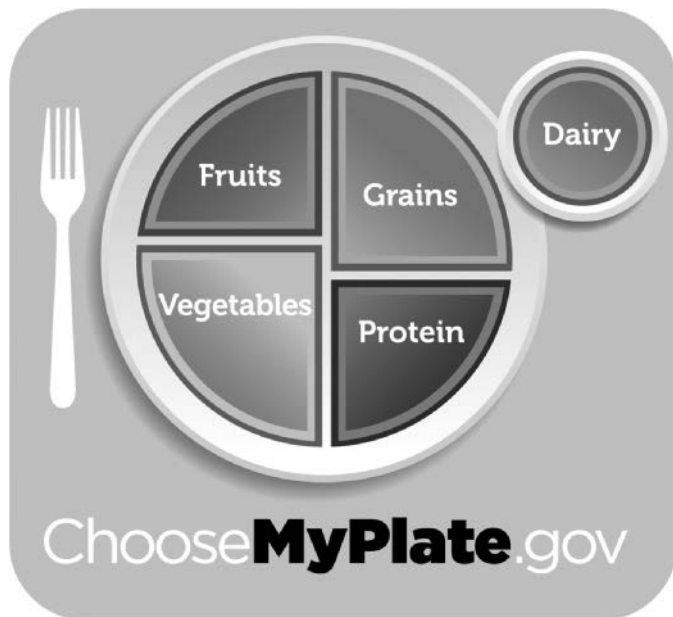
- 150 minutes (2 hours and 30 minutes) each week of moderate-intensity aerobic physical activity (such as brisk walking or gardening)
- 75 minutes (1 hour and 15 minutes) each week of vigorous-intensity aerobic physical activity (such as jogging or swimming laps)
- An equivalent combination of moderate- and vigorous-intensity aerobic physical activity

<sup>†</sup>The guidelines recommend that children and adolescents ages 6–17 do 60 minutes (1 hour) or more of physical activity each day. For adults, do aerobic activity.

of Public Health recommended collapsing the groups to four. This format was accepted by the USDA in 1956 and in 1979 a fifth group—fats, sweets, and alcohol—was added. These plans had two things in common: they were designed to meet nutrient requirements and to prevent nutritional deficiencies. With the recognition of the relationship between diet and chronic disease risk and the development of the DGA, it was important to develop a food guidance system that included recommendations to prevent the excesses or poor food choices associated with chronic disease.

These efforts culminated with the Food Guide Pyramid released in 1992, MyPyramid in 2005, MyPlate in 2011, and MyPlate, MyWins in 2015. The introduction of MyPlate coincided with the release of the 2010 DGA.<sup>141</sup> The MyPlate icon (**Figure 1–1**) depicts the five food groups: fruit, vegetables, grains, protein foods, and dairy foods, but it provides a new, simpler reminder to choose healthy foods at mealtimes than either the Food Guide Pyramid or MyPyramid did. The seven key consumer messages chosen for MyPlate, MyWins is shown in **Table 1–12**.<sup>142,143</sup> The website also has a variety of information about healthy food





**FIGURE 1–1** My Plate Icon.

Courtesy of USDA. Choose My Plate. <http://www.choosemyplate.gov>

choices and videos to provide a visual for individuals. The icon, the new website, and the seven key selected messages were pretested for understanding and general appeal.<sup>144</sup>

MyPlate, MyWins is more than a simple icon; it is “part of a multimodal communication strategy that includes the MyPlate, MyWins Web site with the SuperTracker tool to personalize food plans, consumer educational materials and e-tools, social media engagement, and a partnership initiative to help coordinate and disseminate consistent messages of the DGA.”<sup>145</sup> The website provides easy to understand information on healthy food choices for all ages for both consumers and health professionals. Toolkits for professionals include the “MyPlate Community Toolkit,” which incorporates First Lady Michelle Obama’s Let’s Move! initiative and is designed to help communities reverse the trend of childhood obesity; and the “Eat Healthy Be Active Community Workshop Series,” which builds on the concepts of the DGA by providing detailed tips on how to put recommended behaviors into practice.

## HEALTHY EATING INDEX

The **Healthy Eating Index (HEI)** was developed to provide a single measure to assess diet quality through adherence to the DGA for the U.S. population and the low-income subpopulation.<sup>146–148</sup> Originally developed by the CNPP in 1995 using 1989–1990 Continuing Survey of Food Intakes

### Table 1–12 The Seven Key Consumer Messages Chosen for MyPlate, MyWins

Balancing Calories
Enjoy your food, but eat less
Avoid oversized portions
Foods to Increase
Make half your plate fruits and vegetables
Make at least half your grains whole grains
Switch to fat free or low-fat (1%) milk
Foods to Reduce
Compare sodium in foods such as soup, bread, and frozen meals—and choose the foods with lower numbers
Drink water instead of sugary foods

Reproduced from USDA. Dietary Guidelines 2020: Selected Messages for Consumers. Available at: <http://www.choosemyplate.gov/sites/default/files/printablematerials/SelectedMessages.pdf>.

by Individuals (CSFII) data, it is updated every 5 years as new DGA are released using NHANES data. The updates reflect collaboration between the CNPP and the National Cancer Center. Plans to update the HEI to align with the 2015–2020 DGA are under way. **Figure 1–2** is the fact sheet from the HEI-2010.<sup>148</sup> The scoring metric for the HEI is composed of 12 subcomponents that are summed for a total possible score of 100. Of the subcomponents, nine—total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acid ratios—receive “adequacy scores.” These are foods to encourage and a higher score indicates higher consumption. The three remaining subcomponents—refined grains, sodium, and empty calories (solid fats, added sugars, and alcohol if it exceeds 13 grams/1,000 kcals)—are foods/nutrients to be consumed in “moderation,” and a higher score indicates lower consumption. Recently it was shown, using NHANES 2011–2012 data, that the total population (>2 years of age;  $N = 7,933$ ) had a total score of  $59.0 \pm 0.95$  (standard error); children (2–17 years of age;  $N = 2,857$ ) had a total score of  $55.07 \pm 0.72$ ; and older adults (>65 years of age;  $N = 1,032$ ) had a total score of  $68.29 \pm 1.76$ .<sup>148</sup> In addition to age being associated with better diet quality, HEI scores also are higher in individuals with higher incomes and more education.<sup>149</sup> Overall, diet quality appears to be improving slowly in the United States; it is not clear, however, whether improvement will be rapid enough to meet the all the HP 2020 nutrition goals. Only improvements in whole fruit intake and empty calories appear to be on track to meet these goals.<sup>150</sup>

Tools for researchers, include basic steps to calculate HEI scores at different levels: national food supply, food



HEI-2010 <sup>1</sup> component	Maximum	Standard for maximum score	Standard for minimum score of zero
<b>▲ Adequacy (higher score indicates higher consumption)</b>			
Total Fruit <sup>2</sup>	5	≥0.8 cup equiv./1,000 kcal <sup>10</sup>	No fruit
Whole Fruit <sup>3</sup>	5	≥0.4 cup equiv./1,000 kcal	No whole fruit
Total Vegetables <sup>4</sup>	5	≥1.1 cup equiv./1,000 kcal	No vegetables
Greens and Beans <sup>4</sup>	5	≥0.2 cup equiv./1,000 kcal	No dark-green vegetables, beans, or peas
Whole Grains	10	≥1.5 ounce equiv./1,000 kcal	No whole grains
Dairy <sup>5</sup>	10	≥1.3 cup equiv./1,000 kcal	No dairy
Total Protein Foods <sup>6</sup>	5	≥2.5 ounce equiv./1,000 kcal	No proteing foods
Seafood and Plant Proteins <sup>6,7</sup>	5	≥0.8 ounce equiv./1,000 kcal	No seafood or plant proteins
Fatty Acids <sup>8</sup>	10	(PUFAs + MUFAs)/SFAs ≥ 2.5	(PUFAs + MUFAs)/SFAs ≤ 1.2
<b>▼ Moderation (higher score indicates lower consumption)</b>			
Refined Grains	10	≤1.8 ounce equiv./1,000 kcal	≥4.3 ounce equiv./1,000 kcal
Sodium	10	≤1.1 gram/1,000 kcal	≥2.0 grams/1,000 kcal
Empty Calories <sup>9</sup>	10	≤19% of energy	≥50% of energy

<sup>1</sup> Intakes between the minimum and maximum standards are scored proportionately.

<sup>2</sup> Includes 100% fruit juice.

<sup>3</sup> Includes all forms except juice.

<sup>4</sup> Includes any beans and peas not counted as Total Protein Foods.

<sup>5</sup> Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages.

<sup>6</sup> Beans and peas are included here (and not with vegetables) when the Total Protein Foods standard is otherwise not met.

<sup>7</sup> Includes seafood, nuts, seeds, soy products (other than beverages) as well as beans and peas counted as Total Protein Foods.

<sup>8</sup> Ratio of poly- and monounsaturated fatty acids (PUFAs and MUFAs) to saturated fatty acids (SFAs).

<sup>9</sup> Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is > 13 grams/1,000 kcal.

<sup>10</sup> Equiv. = equivalent, kcal = kilocalories.

**FIGURE 1–2** Fact Sheet for the Healthy Eating Index, 2010

Reproduced from USDA. The Healthy Eating Index. [http://www.cnpp.usda.gov/sites/default/files/healthy\\_eating\\_index/CNPPFactSheetNo2.pdf](http://www.cnpp.usda.gov/sites/default/files/healthy_eating_index/CNPPFactSheetNo2.pdf).

processing, community food environment, and individual food intake. Statistical Analysis System (SAS) macros are available for calculating the HEI–2005 and the HEI–2010.<sup>151</sup>

## THE FOOD LABEL

The Nutrition Labeling and Education Act (NLEA) of 1990 (PL 101-535) amended the Federal Food, Drug, and Cosmetic Act to provide, among other things, that certain nutrients and food components be included on the label. The regulatory authority for the food label rests with the FDA and the Federal Trade Commission. The Secretary of HHS (and by delegation, the FDA) can add or delete nutrients included in the food label or labeling if this action is necessary to assist consumers in maintaining healthy dietary practices.

In response to these provisions, in the Federal Register of November 27, 1991, the FDA published a proposed rule titled “*Food Labeling; Reference Daily Intakes and Daily Reference Values; Mandatory Status of Nutrition Labeling and Nutrient Content Revision.*” In that document, the agency proposed to require that foods bear nutrition labeling listing certain nutrients and the amount of those nutrients in a serving of the food.

Under the NLEA, some foods are exempt from food labeling laws: food served for immediate consumption (e.g., served in hospital cafeterias and airplanes) and sold by food service vendors, (e.g., mall cookie counters, sidewalk vendors, and vending machines); ready-to-eat food that is not for immediate consumption but is prepared primarily on site (e.g., bakery, deli, and candy store items); food shipped

in bulk as long as it is not for sale in that form to consumers; medical foods (e.g., those used to address the nutritional needs of patients with certain diseases); plain coffee and tea, some spices; and other foods with no significant amounts of any nutrients.

Placement of information on the label, type size, manufacturer name and contact information, and other information related to content are also mandated. To accommodate foods sold in small packages, there are special requirements. Further, the USDA regulates poultry in accordance with the Poultry Products Inspection Act and meat under the Federal Meat Inspection Act. Daily values (DV) are one of the key elements of the food label; these are the daily dietary intake standards used for nutrition labeling. The first daily intake standards for the nutrition label, referred to as the U.S. Recommended Daily Allowances, were established in 1973 and were based on the RDAs.<sup>152–154</sup>

Food label criteria continue to change to meet current scientific research and public demand. Another example is the Food Allergen Labeling and Consumer Protection Act of 2004 (PL 108–282, Title II), which mandated that as of January 1, 2006, foods containing or potentially containing any of the eight most common food allergens—milk, eggs, fish, Crustacean shellfish, tree nuts, peanuts, wheat, and soybeans—include the food name on the label in “plain English” (e.g., this product contains EGGS). These foods account for 90% of food allergic reactions in children and adults. The FDA also provides guidance for industry from a standpoint of allergens and potential allergens in the food.<sup>155</sup> Although gluten is not an allergen, in 2013 the FDA set a threshold for gluten of less than 20 parts per million in foods that are labeled “gluten-free,” “no gluten,” “free of gluten,” and “without gluten.”<sup>156,157</sup>

As mandated by the NLEA of 1990, the FDA issued the final food labeling rules for health claims. Updated in 2008, information on the FDA website qualifies and explains claims that can be made for conventional food and dietary supplements. The claims fall into four categories: (1) nutrient content claims; (2) health claims; (3) qualified health claims (QHC); and (4) structure/function claims.<sup>158</sup> Nutrient content claims are fairly straightforward, for example, calorie free: <5 kcal per reference amount customarily consumed (RACC) per labeled serving, or low calorie: <40 kcal per RACC. Further, “when levels exceed 13 g Total Fat, 4 g Saturated Fat, 60 mg Cholesterol, and 480 mg Sodium per RACC, per labeled serving or, for foods with small RACC, per 50 g, a disclosure statement is required as part of claim (e.g., “See nutrition information for \_\_\_ content” with the blank filled in with nutrient(s) that exceed the prescribed levels).<sup>158</sup>

Health claims on foods and dietary supplements are more complicated but can be made after such statements have been reviewed and authorized by the FDA. Before industry can place such a claim on a label, stringent requirements must be met;<sup>159</sup> and all foods allowed to bear such health claims must fulfill specific criteria. The FDA has provided industry guidance on the *evidence-based review system* the FDA uses to evaluate the publicly available scientific evidence for significant scientific agreement on health claims or QHCs and the relationship between a substance and a disease or health-related condition.<sup>159</sup> Approved claims must be clearly stated along with the requirements for the food, the claim requirements, and the model claim; statements are available on the FDA’s website.<sup>159</sup> The FDA has acknowledged that consumers benefit from more information on food labels about diet and health. The FDA thus established interim procedures whereby QHCs can be made for conventional foods and for dietary supplements. Past court decisions

#### Table 1–13a Health Claims Subject to Enforcement Discretion<sup>159</sup>

Calcium, and osteoporosis; calcium, vitamin D, and osteoporosis  
 Dietary fat, and cancer  
 Sodium, and hypertension  
 Dietary saturated fat and cholesterol, and the risk of coronary heart disease  
 Fruits, vegetables, and grain products containing fiber, particularly soluble fiber, and risk of coronary heart disease  
 Fruits and vegetables, and cancer  
 Folate, and neural tube defects  
 Dietary noncariogenic carbohydrate sweeteners, and dental caries; carbohydrate sweeteners, and dental caries  
 Soluble fiber from certain foods, and risk of coronary heart disease  
 Soy protein, and risk of coronary heart disease  
 Plant sterol/stanol esters, and risk of coronary heart disease

#### Table 1–13b FDA Modernization Act Health Claims (Health Claims Authorized Based on an Authoritative Statement by Federal Scientific Bodies)<sup>159</sup>

Whole grain foods, and risk of heart disease and certain cancers  
 Whole grain foods with moderate fat content, and risk of heart disease  
 Potassium, and the risk of high blood pressure and stroke  
 Fluoridated water, and reduced risk of dental caries  
 Saturated fat, cholesterol, and transfat, and reduced risk of heart disease  
 Substitution of saturated fat in the diet with unsaturated fatty acids, and reduced risk of heart disease

have clarified the need to provide for health claims based on less scientific evidence rather than just on the standard of significant scientific agreement (SSA) as long as the claims do not mislead consumers. The FDA began considering QHCs under its interim procedures on September 1, 2003. **Tables 1–13a–b** shows the health claims and QHCs allowed on food labels.<sup>159–160</sup> Finally, structure/function claims are allowed on labels. These differ from health claims in that structure/function claims describe the role of a substance intended to maintain the structure or function of the body. Structure/function claims do not require preapproval by the FDA. Products with structure/function claims must include this disclaimer: “This statement has not been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure, or prevent any disease.” Examples are “calcium builds strong bones” and “antioxidants maintain cell integrity.”

The FDA has proposed new rules that would update the Nutrition Facts labels. This would help consumers make more informed choices. In March 2014, the FDA proposed two rules to update the Nutrition Facts labels, and in July 2015 the FDA issued a supplemental rule that would, among other things, require the percent daily value (% DV) for added

sugars and include a footnote that would help consumers better understand the concept of daily values.<sup>161</sup> **Figure 1–3** shows a comparison of the current with the proposed label. Helping clients understand food labels—including (1) how to use them to make careful food selections, which may reduce or even prevent chronic disease; (2) how the information is especially important to individuals in certain disease states; and (3) how the food in question integrates into a total food plan—is clearly within your purview as a nutrition professional. Information on how to read the food label and consumer information is available online.<sup>162</sup>

## CONCLUSION

Complaints that nutrition recommendations are conflicting and confusing are common; however, these recommendations are remarkably similar across agencies, including the Dietary Guidelines for Americans, the American Heart Association, the American Cancer Institute, and therapeutic diets such as Dietary Approaches to Stop Hypertension. Why? Because the recommendations are based on what the evidence behind the programs dictates. The challenge for all



**FIGURE 1–3** Comparison of Current and Proposed Food Labels

Reproduced from: U.S. Food and Drug Administration. Changes to the Nutrition Facts Label. <http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm385663.htm>. Accessed April 12, 2016

nutritionist professionals is to critically evaluate the scientific evidence before it is translated into public health practice. Nutrition professionals need to use this information to design, execute, and evaluate programs and policies so that positive recommendations are communicated to the public in a unified way. Doing so assures that consumers are getting

the most accurate and comprehensive information available, which allows them to make positive lifestyle changes. This chapter reviewed the science behind public health policies, programs, nutrition education materials, and legislation.

## ISSUES FOR DISCUSSION

1. Dietary recommendations for the public change as scientific studies discover new information. How can these changes be brought to the public in a way that does not confuse them or make them feel resentful?
2. What ethical responsibility, if any, does industry or the media have in assuring the public's health?
3. The Dietary Guidelines for Americans and MyPlate, My Wins promulgate prudent diets, but Americans clearly have difficulty following these recommendations. Why? If people cannot follow them, should we continue to make these recommendations?

## CASE STUDY: EVIDENCE-BASED APPROACH

A number of questions in the nutrition literature have not really been answered using an evidence-based approach; for example: Does fast food intake increase weight in children, and why did the recommendation for intake of added sugars fall from 25% of energy intake in the 2010 Dietary Guidelines for Americans to 10% of energy intake in the 2015–2020 Dietary Guidelines for Americans?

1. Working in teams, pick either of these questions or a question you develop with your instructor.
2. See if you can come to a definitive answer using an evidence-based approach.
3. Present your results.

## ONLINE RESOURCES

1. The World Health Organization's report on the Commission on Ending Childhood Obesity:  
[http://apps.who.int/iris/bitstream/10665/204176/1/978924151-0066\\_eng.pdf?ua=1](http://apps.who.int/iris/bitstream/10665/204176/1/978924151-0066_eng.pdf?ua=1)
2. CDC information on obesity and obesity trends in the United States:  
<http://www.cdc.gov/obesity/data/prevalence-maps.html>
3. Department of Health and Human Services detailed recommendations for physical activity:  
<http://health.gov/paguidelines/guidelines>
4. Public Health Genomics Knowledge Base:  
<https://phgkb.cdc.gov/GAPKB/phgHome.do?action=home>
5. Internet research tips:  
<http://www.library.cornell.edu/olinuris/ref/research/webeval.html>
6. PubMed online tutorials:  
<https://www.nlm.nih.gov/bsd/disted/pubmed.html>
7. Evidence Analysis Library:  
<https://www.andeal.org>
8. Morbidity and Mortality Weekly Report:  
<http://www.cdc.gov/mmwr/mmwrsubscribe.html>
9. Mobile examination center guided tour:  
<http://www.cdc.gov/mmwr/mmwrsubscribe.html>
10. Young Finns study (duplication of Bogalusa Heart Study):  
<http://youngfinnsstudy.utu.fi>
11. NHANES online tutorial:  
[http://www.cdc.gov/nchs/tutorials/nhanes/index\\_current.htm](http://www.cdc.gov/nchs/tutorials/nhanes/index_current.htm)
12. Phytonutrients:  
<https://fnic.nal.usda.gov/food-composition/phytonutrients>

13. NIH's Office of Dietary Supplements:  
<https://ods.od.nih.gov>
14. Interactive DRI for Health Professionals:  
<http://fnic.nal.usda.gov/interactiveDRI>
15. DRI books:  
<https://fnic.nal.usda.gov/dietary-guidance/dietary-reference-intakes/dri-nutrient-reports>

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8. Centers for Disease Control and Prevention. *About Child and Teen BMI*. [http://www.cdc.gov/healthyweight/assessing/bmi/childrens\\_bmi/about\\_childrens\\_bmi.html](http://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html)
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