The Journal of Nutrition
Supplement: USDA Food and Nutrient Databases Provide the Infrastructure for Food and Nutrition Research, Policy, and Practice

USDA Food and Nutrient Databases Provide the Infrastructure for Food and Nutrition Research, Policy, and Practice[1,2]

Jaspreet K.C. Ahuja,* Alanna J. Moshfegh, Joanne M. Holden, and Ellen Harris

Beltsville Human Nutrition Research Center, Agricultural Research Service, USDA, Beltsville, MD

Abstract

The USDA food and nutrient databases provide the basic infrastructure for food and nutrition research, nutrition monitoring, policy, and dietary practice. They have had a long history that goes back to 1892 and are unique, as they are the only databases available in the public domain that perform these functions. There are 4 major food and nutrient databases released by the Beltsville Human Nutrition Research Center (BHNRC), part of the USDA's Agricultural Research Service. These include the USDA National Nutrient Database for Standard Reference, the Dietary Supplement Ingredient Database, the Food and Nutrient Database for Dietary Studies, and the USDA Food Patterns Equivalents Database. The users of the databases are diverse and include federal agencies, the food industry, health professionals, restaurants, software application developers, academia and research organizations, international organizations, and foreign governments, among others. Many of these users have partnered with BHNRC to leverage funds and/or scientific expertise to work toward common goals. The use of the databases has increased tremendously in the past few years, especially the breadth of uses. These new uses of the data are bound to increase with the increased availability of technology and public health emphasis on diet-related measures such as sodium and energy reduction. Hence, continued improvement of the databases is important, so that they can better address these challenges and provide reliable and accurate data. J. Nutr. 143: 241S–249S, 2013.

Introduction

The role of diet and nutrition in the development, prevention, and treatment of noncommunicable diseases such as cancer, obesity, cardiovascular diseases, and diabetes is well documented. According to the WHO, up to 80% of coronary heart diseases, 90% of type 2 diabetes, and 33% of cancers could be prevented through diet and physical activity (1). Food and nutrient databases provide the basic infrastructure for food and nutrition research, nutrition monitoring, and dietary practice (2). In general, these databases may include food descriptions, nutrients or other dietary constituents of interest, and portion weights. The USDA has provided food and nutrient databases for foods in the American diet for over 115 y. These databases are unique, as they are the only databases available in the public domain that support these functions. The Beltsville Human Nutrition Research Center (BHNRC)[3], part of the USDA's Agricultural Research Service (ARS), is responsible for a considerable portion of this work. The purpose of this review

[1] Published in a supplement to *The Journal of Nutrition*. The Supplement Coordinator for this supplement was Jaspreet K.C. Ahuja, USDA. Supplement Coordinator disclosures: Jaspreet K.C. Ahuja and the authors are employed by the Beltsville Human Nutrition Research Center, Agricultural Research Service, USDA. The supplement is the responsibility of the Guest Editor to whom the Editor of *The Journal of Nutrition* has delegated supervision of both technical conformity to the published regulations of *The Journal of Nutrition* and general oversight of the scientific merit of each article. The Guest Editor for this supplement was Kevin Schalinske. Guest Editor disclosure: Kevin Schalinske had no conflicts to report. Publication costs for this supplement were defrayed in part by the payment of page charges. This publication must therefore be hereby marked "advertisement" in accordance with 18 USC section 1734 solely to indicate this fact. The opinions expressed in this publication are those of the authors and are not attributable to the sponsors or the publisher, Editor, or Editorial Board of *The Journal of Nutrition*.

[2] Author disclosures: J. K. C. Ahuja, A. J. Moshfegh, J. M. Holden, and E. Harris, no conflicts of interest.

* To whom correspondence should be addressed. E-mail: Jaspreet.ahuja@ars.usda.gov.

[3] Abbreviations used: AMPM, Automated Multiple Pass Method; ARS, Agricultural Research Service; ASA24, Automated Self-Administered 24-Hour Recall; BHNRC, Beltsville Human Nutrition Research Center; CNPP, Center for Nutrition Policy and Promotion; DHHS, Department of Health and Human Services; DSID, Dietary Supplement Ingredient Database; EPA, Environmental Protection Agency; ERS, Economic Research Service; FICRCD, Food Intakes Converted to Retail Commodities; FNDDS, Food and Nutrient Database for Dietary Studies; FPED, Food Patterns Equivalents Database; FSIS, Food Safety and Inspection Service; FSRG, Food Surveys Research Group; MPED, MyPyramid Equivalents Database; NCI, National Cancer Institute; NDL, Nutrient Data Laboratory; NFNAP, National Food and Nutrient Analysis Program; ODS, Office of Dietary Supplements; RACC, Reference Amounts Customarily Consumed; SR, National Nutrient Database for Standard Reference; WWEIA, What We Eat In America.

Manuscript received October 9, 2012. Initial review completed October 18, 2012. Revision accepted November 9, 2012.
First published online December 26, 2012; doi:10.3945/jn.112.170043.

is to provide the scientific community a comprehensive overview of the USDA's food and nutrient databases; their use in nutrition policy, food and nutrition research, and dietary practice; and the current state of the databases.

USDA's Food and Nutrient Databases

The USDA's role in food composition databases goes back to 1896 when the first comprehensive USDA bulletin was published on the composition of American foods by Atwater and Woods (3). These databases have evolved with the changing American diet, food environment, and public health needs. At present, there are 4 major food and nutrient databases released by 2 laboratories within BHNRC. The Nutrient Data Laboratory (NDL) compiles and disseminates the USDA National Nutrient Database for Standard Reference (SR) and the Dietary Supplement Ingredient Database (DSID), and the Food Surveys Research Group (FSRG) is responsible for the Food and Nutrient Database for Dietary Studies (FNDDS) and the USDA Food Patterns Equivalents Database (FPED) [formerly MyPyramid Equivalents Database (MPED)]. A brief description of each of the databases follows.

USDA National Nutrient Database for Standard Reference (SR)

The SR is the major source of food composition data in the United States. It provides the foundation for most food composition databases used in food policy, research, dietary practice, and nutrition monitoring. This database is updated yearly and the latest version is release 25. It contains data for more than 8000 food items and up to 146 nutrients and food components. The food composition data are derived from USDA contracted analyses, the food industry, and the scientific literature (4). The National Food and Nutrient Analysis Program (NFNAP) generates original analytical data for foods and dietary supplements sampled nationwide through a multi-stage probability sampling plan to support the estimation process, because comprehensive profiles for foods and dietary supplements are not available from other sources (5). Food items consumed specifically by minority population groups, such as Hispanics and Native Americans, and nutrient composition information for single ingredient meat and poultry cuts as mandated by the USDA also have been incorporated into SR. A subset of this dataset, comprising ~3000 food and beverage items for 65 nutrients and food components, provides the basis for the FNDDS, the database used to code dietary intakes and calculate nutrients for the What We Eat In America (WWEIA), the dietary component of the NHANES (4).

Dietary Supplement Ingredient Database (DSID)

The DSID provides information on analyzed amounts of nutrients in dietary supplements used in the US. It is intended mainly for research applications. At present, the database provides analytically validated values for adult and children's multivitamin/mineral products. Work is in progress to expand products available to include (n-3) fatty acid products and prenatal vitamins. One of the main benefits of DSID is that users can merge the data with NHANES datasets to estimate total nutrient intake from food and supplements for the U.S. population. DSID has been developed in collaboration with the Office of Dietary Supplements (ODS) at NIH and other federal agencies (6,7).

In addition to these major databases, NDL also releases special interest databases, where the information may be focused on a specific class of components, generally bioactives of current research interest for a short list of foods (150–500 foods). For example, the USDA Database for the Flavonoid Content of Selected Foods was made available last year. It provides data for 500 food items for 26 selected, commonly occurring compounds organized into 5 classes of flavonoids (8).

Food and Nutrient Database for Dietary Studies (FNDDS)

The FNDDS is a database of foods, their nutrient values, and weights for typical food portions. It is the underlying database for the USDA Automated Multiple Pass Method (AMPM) instrument used for collecting 24-h recalls from the survey respondents in WWEIA, NHANES. FNDDS is used to code the food intake data and calculate the nutrient intakes based on the foods and amounts reported in the survey. The database contains >7000 foods and beverages and 65 food components for each of these foods and >30,000 portion weights. There are no missing nutrient values in the FNDDS. The nutrient values for the FNDDS are derived from the SR. The database is updated biennially and the latest version is FNDDS 5.0, used for WWEIA, NHANES 2009–2010. Though the intent of FNDDS is to code dietary intakes and calculate nutrients for the national survey, WWEIA, NHANES, it is being increasingly used for purposes other than national nutrition monitoring such as the underlying database for the SuperTracker [Center for Nutrition Policy and Promotion (CNPP), USDA], Automated Self-Administered 24-Hour Recall (ASA24) [National Cancer Institute (NCI), NIH], and specialized databases such as FPED and Food Intakes Converted to Retail Commodities (FICRCD) (9).

USDA Equivalents Database (FPED) (formerly MyPyramid Equivalents Database (MPED)

The database translates foods consumed in national dietary surveys into the number of equivalents for the 32 food groups based on dietary guidance. Hence, it provides the ability to assess dietary intakes in relation to the dietary recommendations. The latest release was for WWEIA, NHANES 2003–2004, made available in 2008 (10). The database was retooled for the 2010 Dietary Guidelines. Uses of the database include assessing and monitoring dietary patterns, development of nutrition guidance such as MyPlate and Thrifty Food Plan, monitoring and evaluating Healthy People nutrition objectives, and study of diet-disease relationships.

Additional special purpose databases that translate the foods reported in national surveys into dietary constituents of interest and support specialized research policy needs also are developed and maintained by FSRG. For example, FICRCD was made available in 2011 in partnership with the Economic Research Service (ERS), USDA. The FICRCD converts foods consumed in national dietary surveys to 65 retail-level commodities such as fluid milk, apples, onions, and margarine. ERS uses the FICRCD to estimate retail commodity intakes by different socio-economic groups (11).

Role in national nutrition monitoring

The federal government in the US carries out several nutrition monitoring-related activities. Data from these activities are essential for monitoring the health and nutritional status of the U.S. population and formulating and evaluating policy in the areas of food safety, food fortification, food labeling, and food assistance programs, among others (12–14). USDA has been responsible for nutrition monitoring through food consumption surveys since the National Food Consumption Survey was conducted in 1935 (15). The Department of Health and Human

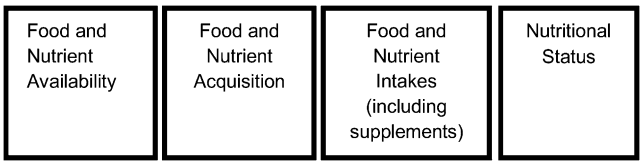

FIGURE 1 Current framework for food and nutrition-related monitoring in the US.

Services (DHHS) has conducted the NHANES program designed to assess the health and nutritional status of the U.S. population since the 1970s. USDA food composition data have been integral for all federal dietary surveys conducted by USDA or DHHS (16). **Figure 1** lists the 4 major elements in the current food and nutrition-related monitoring system in the US by purpose. **Table 1** identifies the federal monitoring system associated with these purposes in the current framework and the role the databases described above play in each of these (17–19).

The National Nutrition Monitoring and Related Research Act of 1990 required the USDA and DHHS to implement a coordinated program of nutrition monitoring activities in the US (14). As of 2002, an integrated NHANES or WWEIA, NHANES is the centerpiece of nutrition monitoring in the US. It provides continuous information on food and supplement intake and nutritional status (biochemical, anthropometric, clinical, and functional) in the US. These data have been extensively used by federal agencies, private industry, and academia for many purposes. A search on PubMed for "NHANES" and "Dietary" yielded ~11,600 results. A brief look at recent publications in the past 3 mo using nutrition-monitoring data indicates a varied scope. It includes the study of food and dietary intake patterns such as examining energy intakes from restaurants (20), usual intake of fish and shellfish (21), trans-fat intakes in the US (22), and dietary intake and dietary quality of low-income adults in the Supplemental Nutrition Assistance Program (23); study of diet-disease relationships such as examining the association between diet quality and cardiovascular risk factors (24), breakfast and obesity (25), and sodium and hypertension (26); and development and validation of research tools such as evaluating and validating a diet quality index (27), among others. Although many of the uses of the data are available in the scientific literature, many of the other uses either do not lend themselves to publication in scientific literature or are not published. Some of the current uses specifically related to the databases are included in the section below.

Other uses and applications

USDA's food and nutrient databases are used for many purposes other than national nutrition monitoring.

Public policy. The databases are used in various aspects of food, nutrition, and health policy. Below are a few examples:

- Dietary recommendations for the U.S. public–These include the Dietary Guidelines for Americans and Dietary Reference Intakes, the basis for federal nutrition policy. Food composition data from the SR, FNDDS, and MPED are key to their development. For example, the addition of choline and vitamin D to the databases led the Institute of Medicine to establish recommendations for these nutrients. They are used to provide food profiles, food sources, and intakes of food groups, nutrients, and dietary components by the U.S. population (28,29). The CNPP, USDA uses the databases to develop nutrition guidance and education for the general public (30). FPED provides a tool to assess intakes of the U.S. population in relation to the dietary recommendations.
- Food assistance programs–The databases play an important role in several aspects of these programs. For example, information from the databases such as added sugars and fat components and research thereof are used to improve USDA's food assistance programs and the Department of Defense's feeding programs. USDA Food Patterns and Thrifty Food Plans (CNPP, USDA), based on FNDDS and MPED, provide meal plans that comply with current dietary guidance at different cost levels and the cost associated, respectively. The Thrifty Food Plan is the basis for Supplemental Nutrition Assistance Program allotments (30). The Child Nutrition Database, developed by the Food and Nutrition Service and based on SR, is used to create plans for meals at schools and daycare centers (31). USDA databases are also used to estimate the cost of reimbursable meals (32).

TABLE 1 Role of USDA's food and nutrient databases in major federal food and nutrition-related monitoring[1]

Purpose	Surveillance system	Key food/nutrition variable	Sponsor agency	Role of USDA databases
Food and nutrient availability	Food and Nutrient Availability Data System	Per capita availability of food energy and 27 nutrients in the U.S. food supply	ERS and CNPP, USDA	SR is used to provide nutrient composition for food available for consumption
Food and nutrient acquisition	National Household Food Acquisition and Purchase Survey	Quantities and nutritional quality of household food purchases and acquisitions	ERS, USDA	SR and FNDDS will be the foundation used to quantify and provide nutrient composition for foods purchased and acquired
Food and nutrient intake	WWEIA, National Health and Nutrition Examination Survey	Per individual intake of food energy and 64 nutrients	NCHS, CDC, DHHS and ARS, USDA	AMPM is used to collect dietary data; FNDDS to quantify and provide nutrient composition for foods consumed
Nutrient intake	Total Diet (Market Basket) Study	Contaminants and 16 nutrients in foods	FDA, DHHS	Selection of foods and quantities consumed based on WWEIA, NHANES consumption data

[1] AMPM, Automated Multiple Pass Method; ARS, Agricultural Research Service; CNPP, Center for Nutrition Policy and Promotion; DHHS, Department of Health and Human Services; ERS, Economic Research Service; FNDDS, Food and Nutrient Database for Dietary Studies; NCHS, National Center for Health Statistics; SR, National Nutrient Database for Standard Reference; WWEIA, What We Eat In America.

- Public health interventions–The databases along with dietary intake data provide the evidence base for public health interventions and evaluation. They are used for risk assessment, modeling different scenarios for various age-sex groups, and impact analyses of programs such as the fortification of grain products with folate, reduction of sodium and trans fat in the U.S. food supply, and Healthy People 2010 and 2020 (33–35). Recently, the FDA used USDA databases for making policy decisions regarding trans fat labeling and the Sodium Reduction in the Food Supply Initiative (36).

Food and nutrition-related research. USDA food and nutrient databases provide the basic infrastructure for all types of dietary research. They are used in a variety of ways. These include:

- Food and nutrient information in the USDA databases underlies several types of research. These may include research based on nutrition monitoring data (as described earlier) and/or may be independent of the nutrition monitoring data. Some recently published research in the latter category includes investigations of diet-disease relationships, as in the study of dietary nitrate and nitrite consumption and risk of thyroid cancer (37); assessment of diet and nutritional status of communities and populations in and outside the US, such as a study of consumption of added sugars in the US (38) and of diets of Tehranian adults (39); analytical composition work, such as characterization of changes in beef in the US (40); and modeling and risk-benefit analyses, such as assessing intake and exposure outcomes of exchanging meat, poultry, or seafood for dietary protein (41), among others. SR has been cited by >3000 papers in 160 peer-reviewed journals since 2000 (42). Similar searches for other databases yielded the following results: FNDDS (550 citations) and MPED (123 citations). The number of citations underestimates the use of the databases in dietary research, as many authors fail to reference the databases or use secondary databases based on the USDA databases. A search on PubMed for the terms "NHANES and dietary" yielded ~11,600 results, whereas the terms "NHANES and dietary and database" yielded only 265 results. Research is also disseminated on organization Web sites and through public documents such as the Mortality and Morbidity Reports by the National Center for Health Statistics and Data Briefs by FSRG.
- USDA databases are used for coding and calculating nutrient intakes for several large-scale, cross-sectional, and longitudinal studies. Some examples include Healthy Aging in Neighborhoods of Diversity Across the Life Span, a 20-y, longitudinal study to understand the sources of persistent health disparities (NIH) and the Upper Columbia River Tribal Consumption and Use Survey, a survey to characterize the nature and extent of environmental contamination and potential exposures in the Upper Columbia River region by the Environmental Protection Agency (EPA) (43,44). The use of the databases in research is expected to grow exponentially as the use of ASA24, described later, increases.
- In recent years, the databases have been used for economic research, such as to study the impact of price on food and nutrient consumption and obesity, intakes of commodities, and the economics of healthy food consumption. The FICRCD described above converts foods reported in WWEIA, NHANES to retail-level food commodities. ERS uses the FICRCD to estimate retail commodity intakes by different socio-economic groups (11). The FDA uses the databases for economic analyses of its proposed regulations (36).

Labeling and regulation. USDA food and nutrient databases play an important role in nutrient labeling of foods and development and assessment of compliance of regulations. These include:

- Food composition data from SR is the primary support for the Food Safety and Inspection Service (FSIS), USDA efforts and those of the retail meat industry to initiate single-ingredient meat labeling in 2012. The retailers can use the data from NDL's Web site for labeling based on the cuts and fat content (6).
- The FDA's voluntary nutrition labeling values for the 20 most frequently consumed raw fruits, vegetables, and fish are based on SR data (45). Hence, the SR data provide a repository of current and accurate values for nutrients in foods, which are consumed by a large proportion of the population.
- Commercial food-labeling software and databases, such as the ESHA Genesis R&D, are based on SR data. These are especially used by small manufacturers, where the cost of analytical data is prohibitive. The FDA does not prohibit food manufacturers from using mean values for labeling purposes and accepts the use of ingredient databases to calculate label values if a manufacturer is confident that the values meet the FDA's compliance criteria (46). The use of SR and FNDDS is expected to grow as new menu labeling requirements for restaurants, part of the Health Care Reform Act, are enforced. In addition, food manufacturers use the database values as reference for nutrient claims.
- Serving size information on all food labels represents the amount of food customarily consumed at one eating occasion or Reference Amounts Customarily Consumed (RACC). The FDA has established RACCs for 139 food product categories based on amounts reported in national surveys (46). The accuracy and validity of the RACCs depend on the food amounts reported by the respondents collected through AMPM and coded using FNDDS.
- Regulatory agencies like the FDA and EPA use exposure assessments and probabilistic modeling to determine the percentile intakes of contaminants or substances of interest. The FDA has recommended that the food industry use these data to support the safety of additives. Its pre-market approval processes for food and color additives require an estimate of probable consumer intake (47). FNDDS foods and intakes are used by the FDA to determine the market baskets for its Total Diet Study, which is designed to determine the intakes of contaminants and elements (19). The EPA has developed and is now updating the Food Commodity Intake Database in partnership with BHNRC for assessment of dietary exposures to pesticide residues. The Food Commodity Intake Database converts FNNDS foods in terms of food commodities rather than as foods consumed (48).
- The use of the databases is not limited to regulations within US. The FAO uses SR data to provide scientific advice to the Codex committees. The Codex commission develops food standards and guidelines to facilitate fair trade and promote coordination on food standards work (49).

Development of tools for research and epidemiological studies. The databases are used as the building blocks or the foundation for developing tools for research. A few examples are described below:

- Commercial nutrient analysis software and databases. Essentially all food composition databases are derived from the SR, e.g., ESHA Database (Joanne Holden, NDL, personal communication, December 2011) and the University of Minnesota's Nutrition Data System for Research (50).
- Specialized databases such as FPED and FICRCD, as discussed above.
- ASA24 (NCI, NIH), a Web-based tool for conducting self-administered 24-h recalls for research studies. ASA24 adapted the AMPM format and design for the Web and uses FNDDS as the underlying database (51). Version 1 of ASA24, released in September 2011, has been used to collect ~25,000 recalls in ~300 studies within a year (Amy Subar, NCI, personal communication, October 2012).
- Healthy Eating Index (CNPP, USDA and NCI, NIH), a measure of diet quality used to assess compliance with Dietary Guidelines for Americans and monitor changes in dietary patterns. It can also be used to study diet-disease relationships and monitor and evaluate public health and community programs (52). FPED (as was MPED) will be used to compute the Healthy Eating Index.
- FFQ for research studies, e.g., the Diet History Questionnaire (NCI, NIH) and Harvard FFQ. USDA databases provide the foundation for the food and nutrient questions and the nutrient values for the foods reported (2).
- International food composition databases maintained by other countries and international organizations utilize USDA food composition databases either as their core data, which is supplemented by country-specific data, or as a supplement to a core database developed by various organizations within a country. Many developing countries, which do not have their own food composition databases, use USDA databases to develop nutrition programs and guidance (53).

Development of food and diet assessment tools for the consumers. The databases are packaged with user-friendly interfaces to make them accessible to the public or health professionals. Examples include:

- Search tools for viewing nutrient profiles for >8000 foods in SR (ARS, USDA) and 13,000 foods in the FNDDS (ARS, USDA).
- Commercial nutrient analysis software and databases used by dietary practitioners and hospitals for patient care or the hospitality industry, such as the Nutritionist Pro or NutriBase, are mainly based on SR (Joanne Holden, NDL, personal communication, December 2011). Weight Watchers uses nutrient profiles from USDA databases for its core data (54).
- SuperTracker and Food-A-Pedia (CNPP, USDA), consumer-friendly interactive online dietary assessment and food information tools. The SuperTracker tracks the foods you eat and compares with your personalized nutrition targets, whereas the Food-A-Pedia provides nutrition information for >8000 foods and allows the consumer to compare them. The SuperTracker has reached >1 million registered users in 9 mo of its public veiling (55). FNDDS and MPED are the underlying databases for these tools (30).
- Software and Web applications that provide interactive meal planning and nutrition education for kids and adults, such as PickChow, PapayaHead, and HUNGRY HIKER Build-A-Meal (56–58). A recent competition, Apps for Healthy Kids, as part of the Let's Move campaign, challenged software developers to develop fun and engaging games to encourage children and tweens to eat better, using the USDA nutrition dataset provided. The dataset included nutrition profiles and MyPyramid food groups for >1000 commonly eaten foods and is a subset of FNDDS and MPED (30).
- Nutrient profiling/food scoring systems. In recent years, many nutrient-profiling or food-scoring or -ranking systems have emerged with the intent to guide individuals in choosing nutrient-dense foods through grocery store shelves or front of pack labeling. These include Yale's NuVal system and the University of Washington's Nutrient-Rich Food Index, among others (59,60). SR and FNDDS are the underlying databases for these systems.

Major Stakeholders and Users

The users of the USDA databases are diverse and include federal and state agencies; consumer groups; for-profit businesses such as the food industry, restaurants, trade organizations, and database and software application developers; nonprofit organizations such as hospitals, academia, and research; and international organizations and foreign governments, among others. The federal agencies include agencies within the USDA such as the CNPP, ERS, Food and Nutrition Service, and FSIS. Non-USDA agencies include the CDC, FDA, and NIH institutes including the NCI and ODS, among others. **Table 2** lists some of these stakeholders and gives examples of the partnerships/projects. The details of some of these projects were discussed in the section above.

Many of these users/stakeholders have partnered with BHNRC to leverage funds and/or scientific expertise to work toward common goals. The center has been successful in building a network of partners and stakeholder involvement. More than one-half of NDL's funding for food analysis research is provided from external sources, whereas most of the supplement ingredient research funding is from external sources. The NFNAP has been conducted by NDL in cooperation with the NIH, CDC, and FDA since 1997. NFNAP's goal is to improve the quality and quantity of analytical data in the USDA food composition databases. Foods that are major contributors of nutrients of public health significance are targeted for nationwide sampling and analysis based on food consumption and composition data (5). NDL routinely collaborates with other labs for developing analytical methods and reference materials and with universities for sampling and analytical work. For example, Virginia Tech and Texas A&M Universities provide sample handling and preparation expertise, while Tufts University partners on vitamin K analysis. Similarly, a consortium of federal agencies, ODS/NIH, ARS/USDA, NCHS/CDC, FDA/DHHS, NCI/NIH, and the National Institute of Standards and Technology of the Department of Commerce, provides leadership for the DSID. ODS, NIH provides almost 100% of the funding for DSID (7). These partnerships build on NDL's expertise in nationwide sampling and expertise in developing food composition databases. Collaborations with the meat industry have enabled the strengthening of the analytical base for beef and pork. These data are the primary support for FSIS efforts and those of the retail meat industry to initiate single-ingredient meat labeling in 2012 and are the official U.S. data for beef marketing, nutrition monitoring, and other studies of the effects

TABLE 2 Major BHNRC stakeholders with examples of partnerships[1]

Stakeholders	Project	BHNRC's role
Federal agencies		
DHHS: NIH, CDC, FDA, and Indian Health Service	NFNAP	Nationwide sampling, data analysis, and compilation of nutrient values for key foods; develop and update food databases on ethnic subpopulations, bioactive components, and dietary supplements (NDL)
CDC, DHHS	WWEIA, NHANES: national nutrition monitoring	Lead responsibility and technical expertise for the WWEIA, NHANES (FSRG)
	Sodium monitoring	Monitoring and tracking sodium in foods (FSRG and NDL)
Food and Nutrition Service, USDA	WWEIA, NHANES: to monitor dietary intakes of low-income U.S. households and food insecurity	Lead responsibility and technical expertise for the WWEIA, NHANES. Persons with low-income are oversampled in the survey (FSRG)
	School Nutrition Dietary Assessment	AMPM is used to collect dietary data, FNDDS to quantify and provide nutrient intake for foods consumed (FSRG)
	Child Nutrition Database	SR is the underlying database (NDL)
FDA, DHHS	Food labeling: fruits, vegetables, and fish; authoritative source for other foods	SR is the underlying database (NDL)
	Exposure assessment, Total Diet Study, RACC, and serving size determination	Uses dietary intakes from NHANES and FNDDS foods and weights (FSRG)
FSIS, USDA	Food labeling: single ingredient meat labeling	Retailer's tables for meat; nationwide sampling, data analysis, and compilation of nutrient values (NDL)
EPA	Food Commodity Intake Database	FNDDS is the underlying database (FSRG)
ODS, NIH	DSID	Nationwide sampling, data analysis, and compilation of nutrient values (NDL)
NCI, NIH	FPED	Based on FNDDS; lead responsibility and technical expertise (FSRG)
	ASA24	Adapted AMPM for the Web; uses FNDDS as the underlying database (FSRG)
National Institute of Dental and Craniofacial Research, NIH	National Fluoride Database	Integrated into SR. Nationwide sampling, data analysis and compilation of fluoride content of foods and beverages (NDL)
National Institute of Aging, NIH	Healthy Aging in Neighborhoods of Diversity Across the Life Span; 20-y duration	AMPM is used to collect dietary data, FNDDS to quantify and provide nutrient intake for foods consumed (FSRG)
ERS, USDA	FICRCD	Based on FNDDS; lead responsibility and technical expertise (FSRG)
CNPP, USDA	Consumer tools: SuperTracker and Food-A-Pedia	FNDDS and MPED are the underlying databases for these products (FSRG)
	Dietary guidance: USDA Food Patterns, Thrifty Food Plans, Healthy Eating Index, Apps for Healthy Kids	FNDDS and MPED are the underlying databases for these products (FSRG)
Academic and research		
Texas Tech and Texas A&M	Analysis of beef cuts to provide nutrient data for nutrition labeling	Development and application of methods for food composition analyses (NDL)
Research Triangle Institute International	Selected smaller studies starting first with a study on local/regional WIC program	AMPM is used to collect dietary data, FNDDS to quantify and provide nutrient intake for foods consumed (FSRG)
Food industry		
National Cattlemen's Beef Association	Currency of beef composition data	Nationwide sampling, data analysis, and compilation of nutrient values (NDL)
International		
Health Canada	Canadian Nutrient File	Most of the composition data for the Canadian Nutrient File is derived from SR (NDL)
	Canadian Community Health Survey, 2004	Modified version of the AMPM was used to collect dietary intakes (FSRG)

[1] AMPM, Automated Multiple Pass Method; ASA24, Automated Self-Administered 24-Hour Recall; BHNRC, Beltsville Human Nutrition Research Center; CNPP, Center for Nutrition Policy and Promotion; DHHS, Department of Health and Human Services; DSID, Dietary Supplement Ingredient Database; EPA, Environmental Protection Agency; ERS, Economic Research Service; FICRCD, Food Intakes Converted to Retail Commodities Database; FNDDS, Food and Nutrient Database for Dietary Studies; FPED, Food Patterns Equivalents Database; FSIS, Food Safety and Inspection Service; FSRG, Food Surveys Research Group; MPED, MyPyramid Equivalents Database; NCI, National Cancer Institute; NDL, Nutrient Data Laboratory; NFNAP, National Food and Nutrient Analysis Program; ODS, Office of Dietary Supplements; RACC, Reference Amount Customarily Consumed; WIC, Women, Infants and Children; WWEIA, What We Eat In America.

of beef in human health. Partnerships also exist with many food manufacturers such as Kellogg's, General Mills, and Campbells. Through these partnerships, the companies provide NDL updated food composition label data for some of their products.

Similarly, FSRG has collaborated with many federal agencies, including the National Center for Health Statistics, ERS, NCI, and EPA and research organizations such as Mathematica Policy Research and Research Triangle Institute. The dietary compo-

nent of NHANES, WWEIA, is conducted as a partnership between FSRG/ARS/USDA and NCHS/DHHS. The DHHS is responsible for the sample design and data collection and the USDA is responsible for the survey's dietary data collection methodology (AMPM), maintenance of the database (FNDDS) used to code and process the data, data review, and processing. The USDA is also responsible for funding for the second day of dietary intake data, needed to develop variance estimates and calculate usual nutrient intakes (12). Similarly, the FPED is being retooled with funding support from several agencies, including NCI and CNPP, and FICRCD was developed in cooperation with ERS. These collaborations draw on the expertise of FSRG staff in developing food and nutrient databases for the national surveys. The cooperators provide scientific consultation and partial resources. These efforts need to be continued and expanded.

Current State of the Databases

The traditional intent of the databases is to provide representative nutrient estimates at both the food composition and food consumption levels. The use of the databases has increased tremendously in the past few years, especially the breadth of uses. They are being increasingly used for purposes they were not originally designed for, such as reporting intakes at individual levels or to assess intakes of foods at an increased level of specificity and detail. There is increasing pressure on the databases to be a continuous tracking mechanism rather than providing snapshots as public health officials look for associations between food supply changes and health outcomes. These new uses of the data are bound to increase with greater availability of technology and public health emphasis on diet-related measures such as sodium and energy reduction.

Keeping up with the pace of changes in the U.S. food system is a major challenge. According to Ng and Popkin (61), there are >85,000 uniquely formulated foods in the marketplace. There is increased consumption of commercially packaged foods, foods away from home, and ethnic and functional foods. The changes in food technology such as functional ingredient formulations, product reformulations, and fortification of products have been tremendous. With these changing needs, variability in nutrient composition and portion size weight data are of concern. Increased specificity and broader coverage is needed in the databases. These changes exacerbate research needs for the databases, especially for brand name or product-specific data, restaurant data, school foods, and ethnic foods. In addition, the currency of the databases is ever more crucial for making policy decisions and keeping up with the fast-paced changes in the food market and food environment.

The databases have met many of these challenges. As part of the NFNAP program, >1200 foods have been analyzed since 1997. These include many commercial brand name foods, ethnic foods such as Latino and Chinese foods, and foods from fast food and regular restaurants. These data from nationwide sampling have replaced old analytical data from published literature and small research studies, thereby improving the statistical power of the data and leading to improvements in accuracy, reliability, and breadth of the data. Similarly, there is an increased emphasis on the inclusion of more commercial brand name and restaurant foods in the FNDDS. These efforts need to be continued and expanded. A comprehensive plan to expand the scientific basis for the data to improve the statistical power of the mean and the variability estimates needs to be developed and implemented. At the same time, databases need to be developed for new, emerging health components.

Sampling one food nationwide and the nutrient analysis costs ~$17–20,000. Internal and external funding cannot keep pace with the depth and breadth of the expanding uses for these databases and the diverse and dynamic U.S. food system. Given budgetary constraints, creative efforts are needed to further address these research challenges. Discussions are needed to plan systems and strategies to systematically deal with these issues.

There needs to be an increased awareness of the role of the databases among the scientific community and policy makers. This is important to ensure continued and enhanced funding. Journals, editors, peer reviewers, and scientists need to be made aware of the importance of the databases. Many authors fail to reference the databases, which masks the magnitude of their impact on research. Increased coordination with research partners and stakeholders is needed to promote their importance. A strategic plan is needed for marketing the databases, including their core values, purposes, goals, objectives, and outcomes.

In conclusion, the USDA food and nutrition databases play an important role in national nutrition monitoring, national food policy, and regulation. They provide the basic infrastructure for food and nutrition research and dietary practice. The users of these databases are diverse and include both public and private stakeholders. Many partnerships and collaborations have been developed with key stakeholders to leverage funds and work toward the common goal of improving the databases. The use of the databases has increased exponentially in the past few years, especially the breadth of uses. The funding for the databases has not kept up with the new and increased uses. These new uses of the databases are bound to increase with greater availability of technology and public health emphasis on diet-related measures such as sodium and energy reduction. The databases have evolved with the changing American diet, food environment, and public health needs. These efforts need to be continued and expanded.

Acknowledgments

The authors thank Dr. Shanthy Bowman, Jan Montville, Dr. Pamela Pehrsson, and David Haytowitz of BHNRC, ARS, USDA for providing information on the databases and their stakeholders. J.K.C.A. and E.H. designed research; J.K.C.A., A.J.M., J.M.H., and E.H. provided essential information and wrote the paper; and J.K.C.A. had primary responsibility for final content. All authors read and approved the final manuscript.

Literature Cited

1. WHO, FAO. Report of the joint WHO/FAO expert consultation on diet, nutrition and the prevention of chronic diseases. World Health Organ Tech Rep Ser. 2002;916.
2. Pennington JAT, Stumbo PJ, Murphy SP, McNutt SW, Eldridge AL, McCabe-Sellers BJ, Chenard CA. Food composition data: the foundation of dietetic practice and research. J Am Diet Assoc. 2007;107:2105–13.
3. Combs GF. USDA Human Nutrition Center, 1978–1982 and coordination of human nutrition research agencies. J Nutr. 2009;139:185–7.
4. USDA, Agricultural Research Service. USDA National Nutrient Database for Standard Reference, release 25; 2012. Nutrient Data Laboratory Home Page [cited 2012 Oct 31]. Available from: http://www.ars.usda.gov/ba/bhnrc/ndl.
5. Pehrsson PR, Haytowitz DB, Holden JM, Perry CR, Beckler DG. USDA's National Food and Nutrient Analysis Program: food sampling. J Food Compost Anal. 2000;13:379–89.
6. Roseland J, Holden J, Andrews K, Zhao C, Schweitzer A, Harnly J, Wolf W, Perry CR, Dwyer JT, Picciano MF, et al. Dietary supplement

ingredient database (DSID): preliminary USDA studies on composition of adult multivitamin-mineral supplements. J Food Compost Anal. 2008;21 Supp. 1:S69–77.
7. USDA, Agricultural Research Service. Dietary Supplement Ingredient Database; 2012. Dietary Supplement Ingredient Database Home Page [cited 2012 Apr 16]. Available from: http://dietarysupplementdatabase.usda.nih.gov/.
8. USDA, Agricultural Research Service. USDA Database for the Flavonoid Content of Selected Foods. Release 3; 2011. Nutrient Data Laboratory Home Page [cited 2012 Apr 16]. Available from: http://www.ars.usda.gov/ba/bhnrc/ndl.
9. Ahuja JKA, Montville JB, Omolewa-Tomobi G, Heendeniya KY, Martin CL, Steinfeldt LC, Anand J, Adler ME, LaComb RP, Moshfegh AJ. USDA Food and Nutrient Database for Dietary Studies, 5.0. USDA, Agricultural Research Service, Food Surveys Research Group, Beltsville, MD; 2012 [cited 2012 Apr 16]. Available from: http://www.ars.usda.gov/ba/bhnrc/fsrg.
10. Bowman SA, Friday JE, Moshfegh A. MyPyramid Equivalents Database, 2.0 for USDA Survey Foods, 2003–2004. Food Surveys Research Group. Beltsville Human Nutrition Research Center, Agricultural Research Service, USDA, Beltsville, MD; 2008 [cited 2012 Apr 16]. Available from: http://www.ars.usda.gov/ba/bhnrc/fsrg.
11. Bowman SA, Martin CL, Friday JE, Clemens J, Moshfegh AJ, Lin B, Wells HF. Retail food commodity intakes: mean amounts of retail commodities per individual, 2001–2002. USDA, Agricultural Research Service and Economic Research Service; 2011 [cited 2012 Apr 16]. Available from: http://www.ars.usda.gov/ba/bhnrc/fsrg.
12. Woteki CE. Integrated NHANES: uses in national policy. J Nutr. 2003;133:S582–4.
13. Sims LS. Contributions of the U.S. Department of Agriculture. Am J Clin Nutr. 1988;47:329–32.
14. Dwyer J, Picciano MF, Raiten DJ. Future directions for the integrated CSFII-NHANES: What We Eat In America-NHANES. J Nutr. 2003;133:S576–81.
15. USDA, Agricultural Research Service. Food Surveys Research Group home page [cited 2012 Apr 16]. Available from: http://www.ars.usda.gov/ba/bhnrc/ndl.
16. National Center for Health Statistics. NHANES I [cited 2012 Oct 31]. Available from: http://www.cdc.gov/nchs/nhanes/nhanesi.htm.
17. USDA. Center for Nutrition Policy and Promotion Home Page, nutrient content of the US food supply 1909–2004. A summary report; 2007 [cited 2012 Apr 16]. Available from: http://www.cnpp.usda.gov/publications/foodsupply/FoodSupply1909–2004Report.pdf.
18. USDA. Economic Research Service [cited 2012 Apr 16]. Available from: http://www.ers.usda.gov/Briefing/SNAP/food_aps.htm.
19. FDA [cited 2012 Apr 16]. Available from: http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/TotalDietStudy/default.htm.
20. Powell LM, Nguyen BT, Han E. Energy intake from restaurants: demographics and socioeconomics, 2003–2008. Am J Prev Med. 2012;43:498–504.
21. Tran NL, Barraj LM, Bi X, Schuda LC, Moya J. Estimated long-term fish and shellfish intake-national health and nutrition examination survey. J Expo Sci Environ Epidemiol. Epub 2012 Oct 10.
22. Kris-Etherton PM, Lefevre M, Mensink RP, Petersen B, Fleming J, Flickinger BD. Trans fatty acid intakes and food sources in the U.S. population: NHANES 1999–2002. Lipids. 2012;47:931–40.
23. Leung CW, Ding EL, Catalano PJ, Villamor E, Rimm EB, Willett WC. Dietary intake and dietary quality of low-income adults in the Supplemental Nutrition Assistance Program. Am J Clin Nutr. 2012;96:977–88.
24. Nicklas TA, O'Neil CE, Fulgoni VL III. Diet quality is inversely related to cardiovascular risk factors in adults. J Nutr. 2012;142:2112–8.
25. Deshmukh-Taskar P, Nicklas TA, Radcliffe JD, O'Neil CE, Liu Y. The relationship of breakfast skipping and type of breakfast consumed with overweight/obesity, abdominal obesity, other cardiometabolic risk factors and the metabolic syndrome in young adults. The National Health and Nutrition Examination Survey (NHANES): 1999–2006. Public Health Nutr. Epub 2012 Oct 3.
26. Yang Q, Zhang Z, Kuklina EV, Fang J, Ayala C, Hong Y, Loustalot F, Dai S, Gunn JP, Tian N, et al. Sodium intake and blood pressure among US children and adolescents. Pediatrics. 2012;130:611–9.
27. Verger EO, Mariotti F, Holmes BA, Paineau D, Huneau JF. Evaluation of a diet quality index based on the probability of adequate nutrient intake (PANDiet) using national French and US dietary surveys. PLoS ONE. 2012;7:e42155.
28. USDA, Center for Nutrition Policy and Promotion. Dietary Guidelines for Americans; 2010 [cited 2012 Apr 16]. Available from: http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf.
29. Institute of Medicine, Food and Nutrition Board. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. Washington, DC: National Academies Press; 2005.
30. USDA, Center for Nutrition Policy and Promotion [cited 2012 Apr 23]. Available from: http://www.cnpp.usda.gov/Default.htm.
31. USDA, Food and Nutrition Service. Nutrient analysis protocols [cited 2012 Apr 16]. Available from: http://www.fns.usda.gov/tn/resources/NAP2.pdf.
32. Murphy SP, Yaktine AL, Suitor CW, Moats S. Child and Adult Care Food Program: aligning dietary guidance for all. Committee to Review Child and Adult Care Food Program Meal Requirements, Food and Nutrition Board, Institute of Medicine of the National Academies [cited 2012 Apr 16]. Available from: http://www.nap.edu/catalog.php?record_id=12959.
33. Dietrich M, Brown CJ, Block G. The effect of folate fortification of cereal-grain products on blood folate status, dietary folate intake, and dietary folate sources among adult non-supplement users in the United States. J Am Coll Nutr. 2005;24:266–74.
34. Doell D, Folmer D, Lee H, Honigfort M, Carberry S. Updated estimate of trans fat intake by the US population. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2012;29:861–74.
35. US Department of Health and Human Services, CDC. Healthy People 2020 [cited 2012 Apr 23]. Available from: http://www.healthypeople.gov/2020/topicsobjectives2020/pdfs/HP2020objectives.pdf.
36. Leighton J. Nutrient databases: critical tools for regulation and policy. National Nutrient Databank Conference, FDA; March 28, 2012 [cited 2012 Apr 16]. Available from: http://www.nutrientdataconf.org/PastConf/NDBC36/7–1_Leighton_NNDC2012.pdf.
37. Aschebrook-Kilfoy B, Ward MH, Gierach GL, Schatzkin A, Hollenbeck AR, Sinha R, Cross AJ. Epithelial ovarian cancer and exposure to dietary nitrate and nitrite in the NIH-AARP diet and health study. Eur J Cancer Prev. 2012;21:65–72.
38. Welsh JA, Sharma AJ, Grellinger L, Vos MB. Consumption of added sugars is decreasing in the United States. Am J Clin Nutr. 2011;94:726–34.
39. Hosseini-Esfahani F, Jessri M, Mirmiran P, Sadeghi M, Azizi F. Does the diet of Tehranian adults ensure compliance with nutritional targets? Observations from the Tehran Lipid and Glucose Study. Public Health Nutr. 2011;14:1539–48.
40. McNeill SH, Harris KB, Field TG, Van Elswyk ME. The evolution of lean beef: identifying lean beef in today's U.S. marketplace. Meat Sci. 2012;90:1–8.
41. Yaktine AL, Nesheim MC, James CA. Nutrient and contaminant tradeoffs: exchanging meat, poultry, or seafood for dietary protein. Nutr Rev. 2008;66:113–22.
42. Wong, YatPing. Search on Scopus by the National Agricultural Library [cited 2012 Jan 12].
43. Evans MK, Lepkowski JM, Powe NR, LaVeist T, Kuczmarski MF, Zonderman AB. Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS): a longitudinal, epidemiologic, urban study of health, race, and socioeconomic status. Ethn Dis. 2010;20:267–75.
44. U.S. Environmental Protection Agency; 2010 [cited 2012 Apr 23]. Available from: http://www.epa.gov/region10/pdf/sites/ucr/tribal_consumption_survey_workplan_ucr_0910.pdf.
45. FDA. Food labeling; guidelines for voluntary nutrition labeling of raw fruits, vegetables, and fish [cited 2012 Apr 23]. Available from: http://www.gpo.gov/fdsys/pkg/FR-2006–07–25/pdf/06–6436.pdf#page=1.
46. FDA. Code of Federal Regulations Title 21 [cited 2012 Apr 23]. Available from: http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=101.12.
47. FDA. Guidance for industry: estimating dietary intakes of substances in foods; 2006 [cited 2012 Apr 23]. Available from: http://www.fda.gov/food/guidancecomplianceregulatoryinformation/guidancedocuments/foodingredientsandpackaging/ucm074725.htm#prob.
48. U.S. Environmental Protection Agency. Food Commodity Intake Database. Food Surveys Research Group Home Page [cited 2012 Apr 16]. Available from: http://www.ars.usda.gov/ba/bhnrc/ndl.

49. Randell AW, Whitehead AJ. Codex Alimentarius: food quality and safety standards for international trade. Rev Sci Tech. 1997;16:313–21.
50. Schakel SF, Sievert YA, Buzzard IM. Sources of data for developing and maintaining a nutrient database. J Am Diet Assoc. 1988;88:1268–71.
51. Subar AF, Kirkpatrick S, Mittl B, Zimmerman TP, Thompson FE, Bingley C, Willis G, Islam N, Baranowski T, McNutt S, et al. The Automated Self-Administered 24-hour Dietary Recall (ASA24): a resource for researchers, clinicians and educators from the National Cancer Institute. J Acad Nutr Diet. 2012;112:1134–7.
52. Bachman JL, Reedy J, Subar AF, Krebs-Smith SM. Sources of food group intakes among the US population. J Am Diet Assoc. 2008;108:804–14.
53. USDA, Economic Research Service; 2010. Assessing the benefits of public research within an economic framework: the case of USDA's Agricultural Research Service. Paul Heisey, John King, Kelly Day Rubenstein, Dale Bucks, and Rick Welsh [cited 2012 Apr 23]. Available from: http://www.ers.usda.gov/Publications/ERR95/ERR95.pdf.
54. USDA, Agricultural Research Service; 2010. Monitoring America's nutritional bottom line [cited 2012 Apr 23]. Available from: http://www.ars.usda.gov/is/AR/archive/mar12/form0312.htm.
55. USDA, Center for Nutrition Policy and Promotion. News Release No.0289.12 [cited 2012 Apr 16]. Available from: http://www.usda.gov/wps/portal/usda/usdamediafb?contentid=2012/09/0289.xml&printable=true&contentidonly=true.
56. ZisBoomBah [cited 2012 Oct 31]. Available from: http://www.zisboombah.com/.
57. PapayaHead[cited 2012 Oct 31]. Available from: http://www.papayahead.com/.
58. Hungry Hiker [cited 2012 Oct 31]. Available from: http://www.dmns.org/nutrition/.
59. Katz DL, Njike VY, Rhee LQ, Reingold A, Ayoob KT. Performance characteristics of NuVal and the Overall Nutritional Quality Index (ONQI). Am J Clin Nutr. 2010;91:S1102–8.
60. Fulgoni VL III, Keast DR, Drewnowski A. Development and validation of the Nutrient-Rich Foods Index: a tool to measure nutritional quality of foods. J Nutr. 2009;139:1549–54.
61. Ng SW, Popkin BM. Monitoring foods and nutrients sold and consumed in the United States: dynamics and challenges. J Acad Nutr Diet. 2012;112:41–5.