

**USDA Agricultural Research Service
National Program 107
Human Nutrition
2024-2029 Action Plan**

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Mission

The mission of National Program 107 (NP 107), Human Nutrition, is to define the role of food and its components in optimizing health throughout the life cycle for all Americans by conducting high-priority national research.

Vision

The vision for the program is that well-nourished Americans make health-promoting diet choices based on scientific evidence.

Relationships of NP 107 to the [USDA FY22-26 Strategic Plan](#)

- The USDA Strategic Plan for FY22-26 includes Goal 4, which addresses providing all Americans safe, nutritious food: ***Objective 4.2- Encourage healthy dietary choices through data-driven, flexible, customer-focused approaches***

Relationship to the 2020-2025 [USDA Science Blueprint Theme 3- Food and Nutrition Translation](#):

- Develop and update the current evidence base to promote proper macro- and micro-nutrient intake among critical age cohorts or regional populations of pregnant women, infants, children, adolescents, working-age adults, Tribal members, seniors, and other groups.
- Provide guidance and incentives to promote healthier diets so that the United States can reduce the incidence of, and morbidity from, obesity and diet-related chronic diseases.

Introduction

Nutrition research has shifted from preventing deficiency diseases to optimizing health and prevention of chronic diseases throughout the life span. NP 107 is well-positioned to work on this research because three of the six Human Nutrition Research centers have Congressionally mandated missions of studying nutrition and its health effects during distinct phases of the lifecycle. Moreover, the separate locations of the Human Nutrition Research Centers facilitate focus on different segments of the population with differing demographics and access to food.

Human nutrition research studies nutrient composition of foods, what people consume; methods to improve precision and accuracy of those assessments; nutrient requirements for all age groups, including pregnant and lactating women; and how nutrition can maintain health throughout the lifespan from conception to old age and prevent the development of diet-related chronic diseases. Unique aspects of the ARS Human Nutrition Program are its work with crop and animal production researchers to determine how changes in farming conditions and practices affect the nutrient content of the American diet; compilation of food composition analysis and its dissemination in databases; and conduct of a nationally representative diet survey of how much and what foods Americans eat. This information is needed by regulatory agencies, health agencies, and health professionals to understand and evaluate how to improve the nutritional status of the American population and its multiple subgroups.

Defining features of NP 107 research include an emphasis on food-based approaches to improving health; the capacity of six internationally recognized Human Nutrition Research Centers with the core capability for long-term, multi-disciplinary, translational research in high priority areas to improve the Nation's health; and premier scientists, state-of-the-science equipment, and facilities for human research across the lifecycle. Unique national resources that are part of NP 107 include [FoodData Central](#), the Food Surveys Research Group that conducts the "What We Eat in America" portion of National Health and Nutrition Examination Survey (NHANES), and a laboratory that develops and improves methods for food analysis. Partnerships with other federal, non-profit, academic, and industry groups enable ARS to leverage funds and build upon common research goals. Development of this Action Plan was informed by an external

review in June 2022 of the previous 5 years' work in NP 107 and a request for feedback from almost 200 stakeholders obtained online via an ARS website in August and September 2022.

The upcoming 5 years will have increased emphasis on the following areas:

1. Multiple-disciplinary research addressing complex problems facing human nutrition and the food system.
2. Increased cooperation with agricultural scientists to understand the effect of production and the environment on human nutrition.
3. Innovative approaches to acquiring new and improved data, including big data and the use of machine learning and artificial intelligence approaches.
4. Increased emphasis on human clinical trials to inform dietary guidance.
5. Precision nutrition approaches, including increased collection and integration of multiple data sources to more precisely inform inter-individual variability in nutritional requirements.
6. Increased emphasis on diet-related chronic diseases, including obesity, diabetes, cardiovascular disease, and cancer.

NP 107 addresses five overarching components:

1. Bridging the Gap between Food Production and Human Health
2. Monitoring Food Composition and Nutrient Intake of the Nation
3. Scientific Basis for Dietary Guidance
4. Prevention of Diet-Related Chronic Diseases
5. Life Stage Nutrition and Metabolism

Component 1: Bridging the Gap between Food Production and Human Health

Accessible, affordable, and nutrient-rich foods are the foundation of healthy diets. Agriculture is the source of food in our diets; because of this, agriculture is the basis for our nutritional status and nutritionally related health status. Agricultural policies, decisions, and procedures, as well as postharvest practices and food processing, determine the types and amounts of foods available to the public; agricultural practices also may affect the nutritional content and appeal of those foods. There is an urgent need to understand how agricultural practices align with healthful dietary patterns and to identify the extent to which agriculture and food production practices and decisions affect the nutrition and quality of food relevant to human nutrition and health. Within ARS, cooperation between national programs in human nutrition and those oriented towards agricultural production provides the synergy to develop sustainable methods of producing foods that will contribute to optimal public health. Moreover, there is increasing recognition that understanding the connections and synergies between nutritional health and agriculture can only be achieved through the broad framework of food systems and simultaneous research across all pillars of the food system.

Problem Statement 1A: Determine Agricultural Practices that Influence the Nutritional Quality and Composition of Food

Agriculture supplies the basic ingredients for our food system and diets and therefore has the potential to affect human health and chronic disease risk. Food is a complex milieu of nutrients and non-nutritive components, and agricultural and environmental factors influence accumulation of these components. Moreover, anti-nutrients and structural components affect the beneficial properties of food.

Research Focus

ARS will examine the effects of genetics, agricultural production management, environment, and processing on both the magnitude and variability of nutritional composition and quality of the U.S. food supply. Many factors have the potential to alter food composition, but the magnitude and variability of changes need to be placed in the context of an integrated and complex food supply to determine if and/or

how they have meaningful effects on human health. Chemical and biochemical analyses of crops grown under different genetic and management conditions are needed, as well as of animal-sourced foods produced by different diets and management programs. Controlled studies are required to accurately assess the effects of environmental variables, including climate, soil, and water, on the quality of foods. We will conduct research to determine the influence of agricultural inputs/decisions on the sensory aspects of food and how changes may alter perceptions of taste and acceptability. Postharvest management and processing technologies will be studied to determine whether they positively or negatively alter foods to a degree that changes their health-promoting properties. Information on the accumulation of components not currently considered nutrients but of potential physiologic importance is needed to inform dietary guidance. Research is needed to understand how production/environmental factors influence concentrations of anti-nutrients and/or metals such as arsenic and cadmium. It will be important to develop analytical information in a uniform manner and in close collaboration with other programs that will allow the data to be placed in publicly accessible databases such as [FoodData Central](#).

Anticipated Products

- Information regarding whether agricultural decisions alter the chemical composition of animal and plant crops in a manner that significantly affects human health and consumer acceptability.
- Studies that evaluate the effect of alternative feeding/management practices on the healthfulness of animal-sourced foods.
- New data on the effects of agricultural production, post-harvest practices and environmental conditions on human nutrition and health status that can be used to make public, private, and scientific policy and decisions that improve the nutritional benefits and sustainability of the nation's food supply.
- Data that help us understand the potential effect of environmental changes on the chemical composition of the food supply.
- Information that provides guidance to the U.S. Food and Drug Administration (FDA) and other regulatory agencies that develop guidelines for the accumulation of potential unhealthy components in food.
- Added information regarding the effect of production and environment on sensory characteristics of food.
- Studies that characterize nutritional effects of common processing technologies.
- Enhanced food composition information in publicly accessible databases, especially [FoodData Central](#).
- Increased collaboration between plant/animal scientists and human nutrition research centers.

Potential Benefits

- Agriculture and the food industry can develop/alter practices to ensure the food supply contains acceptable levels of nutritionally important components.
- Data are available for making informed policy decisions in efforts such as the School Lunch program and the *Dietary Guidelines for Americans*.
- Develop a better understanding of the relationship among animal and plant agricultural production and management, the environment, nutrient quality, and content and human health.
- Enhanced means of food production and processing that result in foods with improved taste, nutritional value, and/or quality and that meet consumer demand.

Problem Statement 1B: Conduct Multiple-disciplinary Research to Understand the Complex Interactions within the Food System and their Impacts on Human Health.

Consensus is emerging that food systems contain four primary, interacting, and interdependent components: human nutrition/health; production agriculture and food technology; effects on and by the environment; and consumer choices and attitudes. Moreover, it is recognized that within a system all

components interact with and have both intended and unintended consequences for other components of the system.

Research Focus

Understanding the complex interactions within the food system related to human health requires the development of multidisciplinary teams that assess inputs and effects from all sectors. Nutrition scientists will develop partnerships with other scientific disciplines, including animal, plant, soil, water, climate, food technology, food safety and social scientists. Emphasis will be on understanding interactions and constraints across the entire system. For example, understanding the benefits and detriments of plant-based diets requires assessment of multiple components, including the effect on water, soil and land resources, consumer expectations, changes in crop rotations, utilization of grazing lands, and the nutritional consequences of not consuming nutrients/components enriched with animal products. Animal and plant production practices that may alter the availability/acceptability of foods, and therefore influence diet selection and quality, need to be identified and measured. There is a need to determine whether these interactions result in altered human body stores and/or changes in physiologic variables. There is a need to understand how altering agriculture to promote optimal human health affects economic and environmental sustainability. In vitro and animal studies may be used to suggest effects and develop hypotheses of how the above affect human health outcomes. When possible, human studies are needed to establish proof of a meaningful effect on human nutrition and disease prevention endpoints.

Anticipated Products

- A greater understanding and appreciation of food systems and the complexities that influence diet-related human health.
- New information regarding how agricultural and processing practices can be utilized to increase the consumption of under-consumed foods such as fruits and vegetables.
- Data that may be used to assess the effect of proposed large-scale dietary changes on all aspects of the food system.
- Multiple-disciplinary teams that develop healthy animal-source foods that are environmentally friendly and acceptable to the consumer.
- Cross-disciplinary agricultural and nutrition research teams that tackle problems of national/international importance relative to the relationship between agriculture and public health.
- Information regarding how agricultural, postharvest, and processing factors may influence nutritional status of humans.
- New information regarding how potential environmental changes might affect human health and how changes in dietary choices might result in environmental change.

Potential Benefits

- Data that underpin guidance on how to mitigate the effects of environmental change on the food supply and nutritional health.
- Improved health resulting from increased consumption of fruits, vegetables, and other currently under-consumed food groups that are recommended in the *Dietary Guidelines for Americans*.
- Develop a better understanding of the relationship among animal and plant agricultural production and management, the environment, nutrient quality and content, and human health.
- Enhanced means of food production yielding foods with improved taste, nutritional value, and/or quality to drive consumer demand.
- Optimization of agricultural products and practices for nutritional and health-promoting value.

Component 1 Resources

- Beltsville, MD
- Boston, MA
- Burlington, VT

- College Station, TX
- Davis, CA
- Grand Forks, ND
- Houston, TX
- Ithaca, NY
- Little Rock, AR

Component 2: Monitoring Food Composition and Nutrient Intake of the Nation

Monitoring food composition and nutrient intake of Americans is essential for determining public policy, developing dietary guidance, conducting nutrition research, and making decisions regarding food production. The food choices Americans make are dynamic and reflect an ever-changing U.S. food supply and population. This requires ARS research to be vigilant, adaptable, and sophisticated to stay at the forefront of this endeavor.

Problem Statement 2A: Provide Food Composition Data

Foundational to characterizing the nutritional intake of Americans is knowledge of the composition of the foods they eat; this has been a function of the USDA since the nineteenth century. Publicly accessible and extensive food composition databases that accurately reflect the breadth and complexity of the U.S. food supply are essential to providing guidance for public policy (e.g., *Dietary Guidelines for Americans*), data for regulatory agencies (e.g., food labeling by FDA), the food industry and product development, academicians, and the American public. The U.S. food supply is fluid and the task of providing timely and accurate food composition data is made complex by constant changes in food regulations and policy, food choices and consumer preferences, food production and processing methods that induce compositional variability, and demographic changes in the American population. It is increasingly important to link compositional data to data from other domains, most notably agricultural production, environmental data, and consumer data, with direct connections to human health outcomes. It is important to understand the magnitude of variability in food composition and whether such variability affects human health. There is a need to characterize foods consumed by ethnic, nutritionally insecure, and other at-risk populations. Data must also reflect increased research and consumer interest in the components of foods that have the greatest positive or negative effects on health. Data must realistically reflect inherent variability and uncertainty. Databases such as FoodData Central will need to develop methods for accepting and assessing the quality of composition data obtained from multiple sources, including individual research/academic laboratories and food/ingredient industries. ARS will work with multiple groups to develop ontologies that are needed to unify terms and searches across multiple-disciplinary domains. Multiple sources of data, from both inside and outside USDA, will be linked to form a 'food data web' that enables efficient searching for specific data types and facilitates use by researchers such as modelers and systems researchers.

Research Focus

Publicly accessible food composition datasets must contain accurate and timely information for the most important essential nutrients, non-nutritive bioactive compounds, components of concern, and dietary supplements. This includes the impact of genetics, agriculture production management, environment, and processing on nutritional composition of the food supply. Nutrients of concern to at-risk and vulnerable populations are especially important. ARS will develop databases with new, improved, and cost-effective methods for obtaining accurate compositional information; they must also have the capacity for crosstalk with other data sources and use with advancing techniques, including machine learning and artificial intelligence. Such developments should include analytical guidelines and standards for industry, federal research laboratories, and academic research laboratories for conducting the bulk of analyses and minimizing the use of commercial laboratories. New and innovative approaches for collecting foods, determining subsampling plans, and presenting data must be devised to minimize reliance on expensive

outside resources. Databases must develop innovative platforms for data evaluation, compilation, and dissemination. There is a need for innovative approaches to search and retrieve data and to connect to relevant external data sources, especially those containing public health, agricultural, and sustainability data. Development and implementation of a relevant ontological framework that allows for search and retrieval of disparate data across diverse domains is essential. Moreover, there is a need for increased communication regarding the development, purpose, and utilization of data available in the various food composition databases. Public and private partnerships are essential for acquisition of new data and expansion and updating of legacy data. Alternative sources of data, such as manuscripts, data developed during research studies, and commodity data, should be considered for inclusion, and structures and procedures should be developed to maintain quality and relevance. Where appropriate, increased emphasis should be placed on compounds and measures that are not traditionally included in datasets but may have health promoting effects (e.g., ‘dark matter’ of food such as oligosaccharides, polyphenols, dietary fiber, protein quality).

Anticipated Products

- Food composition data that accurately reflect the extent and fluidity of the U.S. food supply.
- Increased information for foods not commonly found in the food supply, foods produced under experimental conditions, foods analyzed by novel or experimental methods, foods consumed away from home, and ethnic foods and foods consumed by, preferred, or are particularly nutritive for at-risk populations.
- Food composition data that clearly show the uncertainty and variability in listed components.
- Cost-effective methods of acquiring food composition data.
- Increased information regarding the potential health benefits of compounds not considered nutrients.
- User-friendly, current, and accurate databases of the most important health-promoting components of foods and dietary supplements consumed by Americans.
- Data that relate food composition to environmental, agricultural, and food technology changes.
- Innovative approaches to database architecture that allow for novel means of acquisition and storage of large data sets and linkages to relevant external databases.
- User-friendly data search and retrieval built on a systematic ontological framework that connects across nutrition, agriculture, sustainability, public health, and consumer data domains.
- Data that can be used by the scientific community and federal regulatory and action agencies to generate relationships between food components and health outcomes.
- Improved integration and connectivity with datasets used by NHANES.
- Better communication with stakeholders regarding the purpose and utilization of data.

Potential Benefits

- An expansive, up-to-date knowledge of food and supplement composition that responds to the dynamic nature of the food supply is essential for illuminating the underpinnings of diet to maintain good health and prevent disease.
- The results of these efforts will broaden food composition information that is used for formulating policy, informing regulatory agencies and consumers, designing food and nutrition-based interventions by health professionals, and directing future research needs for the agricultural/food industry, academic researchers, and government scientists.
- These efforts will strengthen public-private partnerships.

Problem Statement 2B: Determine Food Consumption and Dietary Patterns of Americans

“What We Eat in America” (WWEIA) is the nutrition component of the NHANES study. It is conducted in partnership with the Department of Health and Human Service’s National Center for Health Statistics and is the only nationally representative American diet survey. The data are used by national and international government agencies, food industries, and researchers for development of public policy and

dietary guidance, guiding food product development and assessment, and scientific research. ARS will continue to collect, disseminate, and evaluate the nutritional data. However, changing demographics and consumer choices, as well as new uses of, and demands for, data make it essential that ARS adapt new and improved methodologies and technologies for data collection, processing, quality control, and dissemination. In addition to national surveys, research is also needed to understand the barriers and facilitators to eating healthy diets.

Research Focus

Because these data are critical to public policy and a health assessment of Americans, the collection, analysis, and release of accurate and high-quality data must occur on a timely basis. There is potential for improved means of data collection and faster analysis and dissemination of the data. Changing demographics and eating habits (such as increased use of dietary supplements) require expansion of the type and amount of data collected, and changes in the use of data may require changes in format and delivery. Changing nutrients and bioactive components of concern require constant reconsideration of priorities regarding what should be assessed and included in the nutrition survey; this should be coordinated with the collection of food composition data. Developing strategies to encourage healthy eating requires understanding why consumers choose certain foods and why they avoid others. Because such patterns often begin in childhood it is important to conduct research across the lifespan. Research is needed to characterize the eating styles of vulnerable populations.

Anticipated Products

- Timely release of nationally representative data on the food, nutrient, and dietary supplement intake of Americans.
- Increased coordination with groups collecting food composition data to allow for the most accurate intake assessment of the most important dietary ingredients.
- Increased knowledge of the nutrition of Americans in population subgroups.
- Better understanding of why consumers make healthy or unhealthy food choices.

Potential Benefits

- Information from the dietary survey will be used for multiple purposes, including developing national nutritional policy and guidelines, conducting nutritional epidemiology studies, providing foundational data for food and nutrition-based interventions, informing the food/agricultural industry, and directing future research needs.
- These efforts will inform policy makers about nutritional shortfalls and healthful vs. less healthful dietary patterns to inform dietary guidance.

Problem Statement 2C: Develop New and Improved Methods to Analyze Foods and Determine Food and Nutrient Intake

Food composition and food intake data are only as accurate as the methods used to obtain them. Constant advancements and updates in instrumentation, analytical procedures, and survey methodologies are needed to continue to provide the highest quality data.

Research Focus

Analytical methods for components of foods and dietary supplements are constantly in need of development and/or update. ARS will take advantage of new advancements in instrumentation and/or development of new instrumentation to capture information more accurately on foods and/or food intake (e.g., body cameras, wearable devices). There is a need to develop surrogate markers of intake and nutritional status. New or improved social science methodologies will be developed and/or used to assess consumer choice and barriers/facilitators to consuming healthy diets. There is a need to develop/improve survey instruments and questionnaires, focus group methods, and computer-based programs. Development of analytical instruments needs to be tied to priority needs for food composition analysis or

dietary assessment. Artificial intelligence and/or machine learning approaches provide additional tools for conducting such research.

Anticipated Products

- New/updated instruments to gather information on food and nutrient intake.
- New and improved analytical methods for food constituents, essential nutrients, and health-promoting compounds in whole foods.
- Integration of instrumentation with big data approaches
- Enhanced instruments to assess dietary intake, eating behavior, and consumer choice for the purpose of understanding diet and health relationships.
- Cost effective and accurate methods to determine the ‘dark matter’ (i.e., compounds not recognized as nutrients but which may have health benefits) of common foods.
- Innovative and valid methods for better measures of food choices and intake, physical activity, and related variables.

Potential Benefits

- More precise analyses of foods and dietary supplements
- Enhanced profiles of food composition
- More precise estimates of food/nutrient intake in free-living humans
- Better understanding of consumer choice and barriers/facilitators to consuming healthy diets

Component Resources

- Beltsville, MD
- Boston, MA
- Burlington, VT
- College Station, TX
- Davis, California
- Grand Forks, ND
- Houston, TX
- Little Rock, AR

Component 3: Scientific Basis for Dietary Guidance

Dietary Reference Intake values for individual nutrients and the *Dietary Guidelines for Americans* form the basis for federal, state, and local food and nutrition policies. These are used by researchers, health professionals, the food industry, and individual Americans. Strong scientific evidence is needed to provide accurate dietary guidance. Generating this evidence is challenging because of changes in the demographics of the U.S. population, the food supply (including changes in production, processing, and availability), and how and where food is prepared and consumed. It is increasingly recognized that there is large inter-individual variability in responses to diets and environmental influences; such differences in response are not well characterized for many sub-populations. This work is also challenged by publication of sometimes contradictory data regarding specific foods, micro/macronutrients, and disease prevention. There is accumulating evidence that components beyond recognized nutrients (e.g., dietary fiber, flavonoids, live dietary microbes) contribute to optimal health. ARS scientists will utilize population-based and clinical studies with different age cohorts, geographic locations, and demographics, to provide evidence for dietary guidance and will utilize animal and cellular studies to examine specific biological mechanisms.

Problem Statement 3A: Improve the Scientific Basis for Updating National Dietary Standards and Guidelines

Our understanding of the food-related physiologic processes underlying health and the prevention of disease is constantly expanding. We are faced with the need to accumulate new information relating how dietary patterns, specific foods, nutrients, bioactive food components, and physical activity influence these processes. There also is a growing awareness that environmental stressors interact with and alter the response to these inputs. There is appreciation that individual genetic, epigenetic, phenotypic, and microbiome differences influence how dietary intake and physical activity affect health. There is evidence that some substances may exert their effects on health indirectly through alterations of the microbiome and that the microbiome may modify the biological response to dietary components. It is increasingly recognized that many underserved populations have different nutritional responses and requirements, but there is a lack of information for many of these populations and additional research is needed.

Research Focus

More scientific evidence is needed to serve as the foundation for dietary recommendations as they relate to specific life stages, particularly for young children (birth to 24 months), adolescents, and older adults (> 70 years). Researchers will evaluate the quantitative needs for nutrients and bioactive food components and physical activity, the inter-individual variability in those needs, and how those needs change from birth to older age. Validated biomarkers of nutrient intake and nutritional status will be identified to assess dietary exposure. Research will include studies across the lifespan and diverse populations, including underserved and rural populations. Research will focus on dietary patterns, foods, nutrients of concern, and bioactive food components that show good potential for influencing health. In the past, dietary guidance has used a “one-size-fits-all” approach to dietary guidance, but emerging evidence suggests that many subpopulations have differential responses to diets and chronic disease risk. Subpopulations include those delineated by age, sex, physiologic status (e.g., pregnancy), ethnicity, health, genetics, epigenetics, and activity level. Research is needed to better understand the unique nutrient and activity requirements of these subpopulations as well as how to integrate multiple data sources.

Anticipated Products

- Scientific basis for improving estimates of requirements and safe intake ranges of nutrients and other bioactive food components.
- More data on nutrient adequacy and requirements in specific population groups, including underserved and rural populations.
- Data on sources of inter-individual variability (phenotype, genotype, previous dietary intake, microbiota, etc.) with respect to responses to intake of food and its components, to inform algorithms for predicting optimal intake of foods and food components.
- Validated biomarkers for nutrient intake and nutritional status and for health outcome responses to dietary intake and physical activity.
- Estimates of inter-individual variation in nutrient and activity requirements, including the genetic and environmental foundations for such variation, and how such variation affects nutritional requirements.

Potential Benefits

- Enhanced evidence will lead to more accurate recommendations for diet and physical activity for maintenance of health and improved quality of life. These data will inform the Dietary Reference Intakes and the *Dietary Guidelines for Americans*. This information will also be used by the food industry, dietary professionals, health care professionals, and individual Americans.
- The development of more accurate information regarding nutrient needs, activity patterns, and consumer behavior of specific population groups and individuals will allow policymakers to develop improved food and nutrition policies and programs, such as the *Dietary Guidelines for Americans*, MyPlate, and USDA food assistance programs, including the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).

Problem Statement 3B: Identify Mechanisms Whereby Food, Food Components, and Physical Activity Promote Health

Population-based research links dietary patterns, the intakes of specific nutrients or other food components, and physical activity with health maintenance and decreased risk of disease. However, rigorously designed evaluations of the relationships and analysis of the physiologic processes and biological or molecular mechanisms underlying these effects are often lacking or are equivocal. Advances in technology have created new tools and opportunities that afford scientists an unprecedented ability to discern the mechanisms by which these factors promote health and prevent disease. Advanced techniques in genomics, proteomics, and metabolomics, as well as recently discovered physiologic relationships such as host-gut microbiome interactions or inter-organ microRNA-based signaling provide ARS scientists with potentially fruitful, high-impact lines of research.

Research Focus

Researchers will elucidate how foods, nutrients, health-promoting bioactive food components, and physical activity affect metabolic and physiologic factors related to quality of life and longevity. This work will determine how factors such as bioavailability and metabolism influence the efficacy of nutrients/food components for altering biological processes. How these factors change because of physiologic state (e.g., pregnancy, aging and obesity) and are influenced by genotype, microbiome, phenotype, and other environmental factors will be determined. ARS scientists will develop and utilize innovative tools for assessing effects on molecular, cellular, and physiologic mechanisms. Environmental conditions also may modulate the interaction of food components and physiologic processes.

Anticipated Products

- Improved knowledge of the mechanisms whereby foods, food components, and physical activity alter physiological function and promote health.
- Determination of how physiologic states modify these mechanisms.
- Measurements of how bioavailability and metabolism of nutrients and food components modulate physiologic processes in the body.
- Better understanding of how environmental conditions interact with nutritional status and health.
- Human studies leading to new findings about how dietary components and physical activity patterns improve biomarkers of health.

Potential Benefits

- Improved understanding of how foods, food components, and physical activity support health and reduce disease risk will lead to nutrition policies and government programs promoting better health outcomes.
- Knowledge of the relationships among nutrition, physical activity, and health will lead to better estimates of the requirements and recommendations for levels of optimal dietary intake and activity and provide greater understanding of how to tailor recommendations to promote adherence to the *Dietary Guidelines for Americans*.

Problem Statement 3C: Utilize Advanced Technology to Develop and Integrate Multiple Data Sources to More Precisely Inform Nutritional Requirements.

Decades of human nutrition research and advancements in information technology have left us with substantial amounts of data potentially relevant to human nutritional requirements, but assimilation and utilization of these data has been problematic. Recent advances in information technology such as artificial intelligence and machine learning now offer possibilities of searching massive and disparate datasets and integrating all into a coherent framework. Advanced technology is also providing new and more precise methods for collecting data on free-living humans.

Research Focus

Multidimensional data on diet, genetics, epigenetics, microbiomes, environmental factors, and other factors will be integrated using advanced computation, big data analytics, and high-performance computing to understand inter-individual variation in nutrient and activity requirements. Researchers will utilize machine learning and artificial intelligence approaches for the development of algorithms to better understand and predict interactions between food- and nutrition-related data and health outcomes. Validated biomarkers of nutrient intake and nutritional status will be identified to address personalized needs for specific foods and components based on genetic profiles, ethnicity, lifestyle, and physical environment.

Anticipated Products

- Development of algorithms and programs that predict individual responses to food and dietary patterns.
- Improved knowledge of how precision nutrition approaches can be applied to improve human health and prevent diet-related chronic diseases.

Potential Benefits

- Better tailored nutritional recommendations such as the *Dietary Guidelines for Americans* to be more inclusive of data representing subpopulations such as underserved populations.

Component Resources

- Beltsville, MD
- Boston, MA
- College Station, TX
- Davis, CA
- Grand Forks, ND
- Houston, TX
- Little Rock, AR

Component 4. Prevention of Diet-Related Chronic Diseases

Chronic disease is a major component of health-related costs to the U.S. economy. Diet-related chronic diseases such as obesity, type 2 diabetes, osteoporosis, and some cardiovascular diseases and cancers are major public health concerns in the United States. Six in 10 Americans have a diet-related chronic health condition. In addition, more than 70 percent of U.S. adults are overweight or obese, which increases risk for diabetes, some cardiovascular diseases, and cancers. Moreover, racial, and ethnic minority groups, as well as those living at lower socioeconomic levels, are disproportionately affected by diet-related chronic diseases (e.g., higher rates of hypertension in non-Hispanic Black adults and higher rates of diabetes in American Indians and Alaska Natives).

Problem Statement 4A: Identify Mechanisms Whereby Food, Food Components, and Physical Activity Help Prevent Diet-Related Chronic Diseases such as Obesity, Diabetes, Cardiovascular Disease, and Cancer

The increase in diet-related chronic disease is complex and of multi-etiological origin. Causative factors include dietary, biological, behavioral, economic, and environmental determinants. Further, the influence of dietary components and physical activity on health is the product of a myriad of intertwined physiologic pathways that need to be understood to provide a well-founded evidence base for dietary guidance. There is a need to further investigate the mechanisms by which diet and physical activity can influence chronic diseases so that effective diet-, activity-, and science-based policy solutions to these problems can be developed. Animal and cellular studies are needed to identify basic mechanisms of action and develop hypotheses, and well designed and controlled human clinical trials are needed to test

hypotheses related to the influence of dietary interventions on biomarkers of health and disease, as well as biomarkers of mechanisms of action.

Research Focus

Research is needed to understand the integrated roles of physical activity, dietary patterns, specific foods, and dietary components for mitigation of diet-related chronic diseases. Studies will explore the associations between biological, genetic, and physiological mechanisms linking diet and/or physical activity and chronic disease. ARS scientists will develop and utilize innovative tools for assessing effects on molecular, cellular, and physiologic mechanisms. Studies performed in animals and in cell culture, and human trials (when applicable) will elucidate the role of specific processes that contribute to the prevention of diet-related chronic diseases. The results will provide robust, evidence-based information for informing dietary guidance.

Anticipated Products

- Identification of dietary patterns, specific foods and food components and their mechanisms of action in promoting health and preventing diet-related chronic diseases.
- Scientific basis for understanding the relationship between diet and physical activity and the risk of diet-related chronic diseases.
- Understanding of sources of inter-individual variability in response to diet and the effects of diet on risk for chronic diseases.

Potential Benefits

- Increased knowledge of the relationships between diet and chronic disease will facilitate the design of effective preventive strategies for Americans and provide more accurate dietary and health advice.
- Greater understanding of social and environmental influences will provide the scientific basis to inform public policy and public health efforts at the federal, state, and local level for the purpose of reduction of diet-related chronic diseases in the United States.

Problem Statement 4B: Develop and Evaluate Dietary and Physical Activity Strategies to Prevent Chronic Diseases

Factors that influence food choice and physical activity are varied and complex. Effective guidance requires understanding of both behavioral and physiological factors influencing food choice and physical activity. Research must be directed toward understanding individual barriers to consuming a healthy diet and achieving a healthy body weight. To date, most interventions have generally not been effective or sustainable at a group level. Researchers must develop a better understanding of the social, environmental, and cultural processes that guide individuals to adopt and sustain healthful food choices, eating behaviors, and physical activity patterns such as those recommended in the *Dietary Guidelines for Americans* (<https://www.dietaryguidelines.gov/>).

Research Focus

ARS research will identify and evaluate methods of promoting diet and physical activity change in diverse populations. There is a need for research on single and multi-component interventions to identify effective methods of change for healthier lifestyles and prevention of diet-related chronic diseases. Innovative methodologies that consider the individual and their context (e.g., just-in-time adaptive interventions, digital health technologies, implementation science approach, personalized behavioral interventions) should be considered. Scientists will develop a greater knowledge base of how solutions for prevention of diet-related chronic disease are influenced by socio-demographic, environmental, economic, psychological, and biological factors.

Anticipated Products

- Demonstration through human studies that healthy diets and/or physical activity can improve biomarkers for diet-related chronic diseases.
- Identification of factors that sway eating behaviors, food choice, physical activity, and adherence to the Dietary Guidelines for Americans. This work includes recognition of dietary and biological contributors that influence eating behavior and satiety.
- Increased understanding of the role of demographic, social, environmental, economic, behavioral, and biological factors in achieving and sustaining healthy dietary choices and/or physical activity.
- Proven, effective, and sustainable methods for engaging social, community, and individual change to prevent diet-related chronic diseases, including use of all forms of technology.

Potential Benefits

- Development of accurate measures of eating behaviors and physical activity in addition to generation of solutions for promoting change in these variables will allow policy makers to allocate and leverage resources effectively to reduce diet-related chronic diseases in diverse groups in the United States.
- Enhanced understanding and accurate assessment of how foods, food components, the timing and amount of food intake, and physical activity influence diet-related chronic disease risk will be used by other federal agencies and for informing the *Dietary Guidelines for Americans* and increasing compliance with these guidelines.
- Successful intervention strategies will enable individuals, families, and communities to sustain healthy behaviors, prevent obesity and its subsequent diseases in diverse groups, and reduce health care costs in the United States.

Component Resources

- Beltsville, MD
- Boston, MA
- Burlington, VT
- College Station, TX
- Davis, CA
- Grand Forks, ND
- Houston, TX
- Little Rock, AR
- Stoneville, MS

Component 5: Life Stage Nutrition and Metabolism

The six ARS Human Nutrition Research Centers have different focus areas that cover the age range from infants and children, adolescents, adults, through the aging population. Three of the six ARS Human Nutrition Research Centers have Congressionally-mandated missions to focus their work on specific portions of life, namely pregnant and lactating women, children, and the elderly. In addition to determining nutrient and physical activity requirements for these groups, enhanced understanding of metabolic processes in early and late life that differ from usually studied young adults is essential to develop more relevant recommendations, government policies and programs, and to contain health care costs. One aspect of this is the concept of “nutritional programming” that occurs during periods of development and can result in long-term alterations of gene expression and future changes such as the slow loss of muscle mass among the elderly that leads to reduced calorie needs, frailty, and higher medical costs.

Problem Statement 5A: Identify Dietary and Related Lifestyle Impacts for Healthy Development and Function from Conception to Old Age

Food and its components are essential to the fundamental processes of healthy development and aging. There are multiple gaps in our knowledge of these relationships in humans such as an understanding of human milk composition and its effect on growth and development, the role of protein and micronutrients on maintenance of skeletal and muscular health during aging, and how maternal diets affect childhood obesity. These gaps limit the ability to make authoritative recommendations for nutrient requirements, dietary composition and patterns, and lifestyles that lead to health. With expansion of the aged population in the United States, more people suffer from declines in vision (such as cataracts and age-related macular degeneration), immune function, cognition, and musculoskeletal capability. Subsequently, there is greater demand for characterizing diet and lifestyle requirements that help maintain health and quality of life. Other data are essential to define the mechanisms by which foods and food components regulate metabolism, development, growth, and senescence. In many cases, identifying specific mechanisms requires use of animal and cell culture models and it is important that appropriate models are utilized.

Research Focus

ARS will discover how maternal, antenatal, and postnatal health outcomes are influenced by maternal nutrition and lifestyle. We will investigate the fundamental mechanisms by which food components and physical activity influence growth, neurological development, and aging and how dietary requirements change throughout the life cycle. Studies will be performed in humans as well as in animal and cell culture models. New models are needed to assist with the discovery of the sites of action of bioactive food components. Given the increased prevalence of obesity among all age groups, there is a need to define changes in energy metabolism that occur throughout life and how energy intake alters developmental and aging outcomes. There is a need for solutions to prevent age-related declines in cognitive ability, cardiovascular function, immune function, bone health, muscle strength, physical activity, and vision, among others.

Anticipated Products

- Accurate assessments of dietary, genetic, microbiome and lifestyle influences on maternal/child outcomes.
- Development/refinement of analytical methods for analyzing human milk composition, and its effect on growth and development.
- Development of dietary and activity-based methods to improve cognition, cardiovascular risk factors, bone health, vision, immunity, and muscle strength in older Americans.
- Increased insight of mechanisms by which diet, nutrition, and physical activity influence cellular function, physiology, metabolism, behavior, and health of individuals at different life stages.
- Development/refinement of tools and models to investigate changes in metabolic status at all stages of the lifespan, including growth, development, and aging, and how these affect nutrient requirements.
- Longitudinal data on normal development and aging in the context of diet, nutrient intake, and health outcomes.

Potential Benefits

- The results of this research will provide the understanding required to adopt evidence-based recommendations for individuals at all ages, so they can better adapt to the metabolic and physiologic changes that occur throughout the lifespan and enjoy improved health.
- Data generated by ARS scientists will be used to inform the Dietary Reference Intakes and *Dietary Guidelines for Americans*, and to form the basis for recommendations from health professionals and policy makers.

Problem Statement 5B: Understand the Role of Diet and Physical Activity on Metabolic Programming

Mammalian development proceeds via a specific series of irreversible steps from conception to adulthood that affects body structures, functions, and gene expression patterns. The irreversible nature of biological development involves diverse critical windows that are developmental periods during which specific milestones must be achieved to lay the groundwork for subsequent steps. While diet has a fundamental role in these developmental processes, there are relatively few data on the nutritional requirements and/or the mechanisms through which foods and food components function during these critical windows. Research on nutritional programming will lead to dietary recommendations during periods of development to optimize both short- and long-term health.

Research Focus

Improved knowledge of mammalian development and the specific mechanisms by which nutrients affect these processes is necessary to develop nutritional interventions and strategies to enhance health during different life stages. We will investigate mechanisms regulating developmental alterations in cell number, intercellular signaling, tissue remodeling, and epigenetic regulation. Researchers also need to identify the critical windows during which nutritional deficiency and adequacy induce long-term or permanent changes in mammalian structure, function, and gene expression, as well as the specific nutrients and food components that affect developmental outcomes. There is a need to determine the extent to which nutritional programming influences physiologic processes that modulate chronic disease risk throughout the lifespan. Researchers will elucidate the complex relationship between maternal nutrition and nutrition of the fetus and infant. More data are needed to understand the relationship of nutritional programming as it relates to nutrition-related chronic disease development in children and adults. Human biomarkers need to be identified that can serve as indicators of nutritional exposures and nutritional programming during critical developmental periods.

Anticipated Products

- More accurate information about the fundamental mechanisms responsible for long-term development and molecular regulation of organ structure, function, and metabolism, and an improved understanding of how specific nutrients and other food components induce permanent changes in these processes.
- Enhanced knowledge of the critical periods of development during which targeted nutritional and physical activity interventions are most likely to have long-term health benefits on development, growth, and diet-related chronic diseases.

Potential Benefits

- More complete understanding of specific mechanisms, critical developmental periods, nutrients, and food components important to nutritional programming will enable the development of nutritional interventions and strategies that promote physical and cognitive health and well-being throughout the lifespan.
- New insights into dietary strategies for the prevention of obesity and reduction of diseases such as obesity, heart disease, cancer, bone disorders, and type 2 diabetes.

Component Resources

- Boston, MA
- College Station, TX
- Davis, CA
- Houston, TX
- Little Rock, AR