

National Institutes of Health NUTRITION RESEARCH

REPORT



2020–2021



National Institutes of Health

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I. Executive Summary

The mission of the National Institutes of Health (NIH) is to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability. NIH supports and conducts a broad array of transformative and impactful research studies to better understand nutrition and how it relates to human health and disease. This research focuses on understanding how nutrients and food components are ingested, digested, absorbed, metabolized, stored, and excreted and their overall impact on the body. It also includes research studies to better understand the effects of behavior, including eating and food choice, and environmental exposures on nutritional status.

The NIH Nutrition Research Report summarizes nutrition research activities supported and conducted by NIH in Fiscal Years 2020 (FY20) and 2021 (FY21). This report was compiled and produced by the NIH [Office of Nutrition Research](#) (ONR), which is located in the Division of Program Coordination, Planning, and Strategic Initiatives in the NIH Office of the Director. ONR leads NIH-wide strategic planning and development of nutrition research initiatives.

NIH's total investment in nutrition-related research was approximately \$2.0 billion in FY20 and \$2.1 billion in FY21. Nutrition research funding increased by approximately \$510 million—a 25 percent overall increase—from FY14 to FY21 (Source: Categorical Spending—Nutrition, [NIH Research Portfolio Online Reporting Tools \(RePORT\)](#)). Approximately half of the nutrition-related projects in FY20 and FY21 were related to prevention or obesity.

NIH-supported nutrition research has led to several important discoveries. Many of these findings are announced in [NIH News Releases](#) or published in [NIH Research Matters](#), a biweekly update of NIH research highlights from the NIH Office of Communications and Public Liaison. Highlights related to nutrition from FY20 to FY21 include the following:

- ▶ [A high-fiber diet may improve the response of melanoma patients to immunotherapy](#): A study led by researchers at the National Cancer Institute's Center for Cancer Research found that a diet rich in fiber may help some patients being treated for melanoma respond to immunotherapy treatment by influencing the gut microbiome.
- ▶ [NIH scientists identify a nutrient that helps prevent bacterial infection](#): Scientists from five institutes at NIH studied the body's natural defenses against bacterial infection and identified a nutrient—taurine—that helps the gut recall prior infections and kill invading bacteria. This discovery could aid efforts to find alternatives to antibiotic treatment.

Nutrition-related scientific meetings, workshops, and symposia play a key role in the advancement of nutrition science by providing an opportunity to identify critical research gaps and scientific priorities, as well as disseminate research findings to the scientific community and the public. During FY20 and FY21, NIH sponsored several nutrition-related events, including the following:

- ▶ [Precision Nutrition: Research Gaps and Opportunities Workshop](#)
- ▶ [Food Insecurity, Neighborhood Food Environment, and Nutrition Health Disparities: State of the Science Workshop](#)
- ▶ [Conflicting and Controversial Health Information in the Media: Content, Exposure, and Effects](#)

NIH- and governmentwide collaborations and public-private partnerships were critical to the development of nutrition-related research, strategic planning, and technology transfer initiatives during FY20 and FY21. These collaborations are critical to effectively utilize resources and harmonize the federal nutrition research agenda. Examples of such collaborations include the Interagency Committee on Human Nutrition Research, the National Collaborative on Childhood Obesity Research, and the NIH Nutrition Research Coordinating Committee.

NIH is committed to fostering innovative research and training to advance the field of nutritional science, with the goal of promoting and improving health. Each NIH institute, center, and office (ICO) plays an integral role in accomplishing this mission, and each has shared its research directions as they pertain to nutrition. This comprehensive report serves to be informative and to stimulate new ideas and discoveries.

II. Introduction

The National Institutes of Health (NIH), part of the U.S. Department of Health and Human Services (HHS), is the nation's medical research agency. NIH is made up of 27 institutes and centers (ICs), each with a research agenda that often focuses on specific diseases or body systems. NIH supports biomedical and behavioral research and training in nutrition as it relates to human development, health maintenance, disease prevention, and disease treatment.

Nutrition is a factor in many diseases and an integral part of overall health, development, and well-being. As a result, research interests in the nutritional sciences extend far beyond those of a single institute. Biomedical and behavioral nutrition research and training in FY20 and FY21 was supported by 24 NIH ICs and the NIH Office of the Director.

The NIH nutrition research portfolio includes extramural and intramural research as well as research training. In FY21, 81 percent of the nutrition research portfolio was extramural research, conducted by hundreds of institutions in the United States and in several countries across the world. Many of the research projects funded by NIH are based on ideas developed by individual investigators from institutions of higher education, independent hospitals, and other research organizations. Most of the intramural research was performed in laboratories on the NIH campus in Bethesda, Maryland—including the Clinical Center. NIH also has research facilities throughout the country.



III. Office of Nutrition Research

Over the past several years, NIH has been bolstering nutrition research because of the role that nutrition plays in health and disease. In 2015, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), one of 27 NIH ICs, established the [Office of Nutrition Research](#) (ONR) to accelerate progress in nutrition research. In May 2020, [NIH announced](#) its first agencywide [2020-2030 Strategic Plan for NIH Nutrition Research](#), with the goal of further advancing this area of science and addressing diet-related diseases across the lifespan. It emphasizes cross-cutting, innovative opportunities for advancing nutrition research across a wide range of areas, from basic science to experimental design to research training. The plan is organized around a unifying vision of precision nutrition research and includes four strategic goals and five cross-cutting research areas. These opportunities complement and enhance ongoing research efforts across NIH to improve health and to prevent or combat diseases and conditions affected by nutrition.

Given the importance of nutrition research to human health and disease, on January 8, 2021, then-NIH Director Francis S. Collins, M.D., Ph.D., announced that ONR would be transferred from NIDDK to the Division of Program Coordination, Planning, and Strategic Initiatives (DPCPSI) within the NIH Office of the Director. DPCPSI has a statutory mandate to identify emerging scientific opportunities, rising public health challenges, and existing knowledge gaps that deserve special emphasis and would benefit from strategic coordination and planning. Nutrition research is aligned with the scope of this mandate. Prior to that announcement, NIH sought public comment on the proposed transfer of ONR from NIDDK to DPCPSI via a [Federal Register notice](#) in December 2020. The response from the public and the nutrition research community was overwhelmingly supportive. This transfer to DPCPSI was also supported by the Council of Councils, an NIH advisory group, during a [special meeting on December 30, 2020](#).

The mission of ONR is to advance nutrition science to promote health and to reduce the burden of diet-related diseases and nutrition health disparities. To this end, ONR—

- ▶ Coordinates implementation of the [2020–2030 Strategic Plan for NIH Nutrition Research](#) and evaluates progress toward its goals, objectives, and crosscutting research areas
- ▶ Identifies research projects that deserve expanded effort and support from NIH ICs
- ▶ Develops, leads, and manages NIH-wide nutrition research projects in collaboration with the ICs
- ▶ Represents NIH on intradepartmental or interagency committees on nutrition research and related policy issues
- ▶ Advises NIH leadership and other key officials on matters relating to research on nutrition



IV. NIH Nutrition Research and Funding

OVERVIEW

NIH is the leader in federally supported nutrition research and training. In FY19, FY20, and FY21, NIH provided a total of \$1.9, \$2.0, and \$2.1 billion, respectively, toward these efforts. These amounts represent the combined individual contributions of 24 NIH ICs and the NIH Office of the Director. In FY21, NIH funded nutrition research in 50 states, the District of Columbia, two U.S. territories, and 19 foreign countries. NIH supported approximately 2,000 nutrition-related clinical studies in FY21.

NIH NUTRITION RESEARCH REPORTING

The FY20 and FY21 nutrition research and training information in this report—including grants, contracts, and other funding mechanisms—was obtained using the NIH Research Portfolio Online Reporting Tools ([RePORT](#)) and NIH RePORT Expenditures and Results ([RePORTER](#)) systems, which

are publicly available open-source databases. Additional information about these databases, as well as the methodology for how the data within this report were obtained, are both available in [Section X](#).

NUTRITION RESEARCH AND TRAINING EXPENDITURES

Trends: Fiscal Years 2019–2021

As a percentage of total NIH spending, nutrition research funding has been stable at approximately 5 percent [since FY15](#). [Table 1](#) shows total NIH nutrition research and training support in current and constant dollars. Actual obligations for nutrition research and training by the ICs for FY19–FY21 are shown in [Table 2](#). NIH nutrition research funding increased by almost \$135 million (7 percent) from FY19 to FY21, but the increase was not a uniform trend across individual ICs.

The most recent nutrition research and training expenditures for the ICs in FY21 are shown in [Table 3](#) as total funding amounts and percentages of their total obligation. The number of projects at each IC that supports nutrition research is also included.

Table 1. Actual Obligations for NIH Nutrition Research and Training in Current and Constant Dollars and as a Percentage of Total NIH Obligations, Fiscal Years 2019–2021 (in thousands of dollars)

Fiscal Year	Nutrition Research and Training, Current Dollars ^a	Nutrition Research and Training, Constant Dollars ^b	Actual Total NIH Obligations ^c	Constant Nutrition Dollars as a Percentage of Actual Total NIH Obligations
2019	\$1,931,268	\$1,931,268	\$39,380,856	4.9
2020	\$2,047,194	\$1,898,985	\$41,524,839	4.6
2021	\$2,065,040	\$1,858,775	\$42,738,079	4.3

^a Source: NIH RePORTER. Total excludes intramural research conducted at the NIH Clinical Center.

^b Based on the Biomedical Research and Development Price Index, Fiscal Year 2019 equals 100 percent.

^c Source: [NIH Budget Office Actual Total Obligations by Institute and Center FY00–FY21](#).

Table 2. Funding for Nutrition Research and Training in Current Dollars by NIH Component, Fiscal Years 2019–2021 (in dollars)^a

Institute/Center ^b	Fiscal Year 2019	Fiscal Year 2020	Fiscal Year 2021
FIC	\$2,879,908	\$2,986,711	\$2,406,345
NCATS ^c	\$2,021,477	\$4,079,511	\$4,088,748
NCCIH	\$23,808,248	\$23,108,654	\$21,449,270
NCI	\$154,860,699	\$156,124,544	\$154,938,472
NEI	\$16,517,173	\$18,207,429	\$18,672,702
NHGRI	\$9,899,408	\$10,084,796	\$10,408,983
NHLBI	\$249,133,384	\$242,316,151	\$251,887,494
NIA	\$172,484,624	\$202,494,194	\$192,905,133
NIAAA	\$24,844,078	\$34,550,997	\$24,810,596
NIAID	\$68,342,792	\$89,631,837	\$105,298,717
NIAMS	\$19,650,561	\$19,071,152	\$18,057,228
NIBIB ^c	\$2,776,743	\$2,944,864	\$2,640,356
NICHD	\$113,194,663	\$118,101,158	\$115,079,645
NIDA	\$10,860,135	\$20,790,720	\$14,517,299
NIDCD	\$21,954,833	\$23,371,655	\$23,983,492
NIDCR	\$18,149,596	\$16,693,709	\$13,816,475
NIDDK	\$635,176,819	\$657,605,863	\$703,872,514
NIEHS	\$66,421,739	\$80,489,617	\$77,417,359
NIGMS	\$77,204,080	\$88,111,575	\$77,721,456
NIMH	\$38,135,532	\$37,522,672	\$31,775,902
NIMHD	\$34,254,223	\$33,451,863	\$44,085,247
NINDS	\$31,683,198	\$38,940,040	\$31,498,709
NINR	\$16,045,979	\$17,917,422	\$20,174,680
NLM ^c	\$1,192,561	\$993,610	\$1,400,420
OD ^d	\$119,775,082	\$107,603,430	\$102,132,784
FY Total	\$1,931,267,535	\$2,047,194,174	\$2,065,040,026

^a All amounts are from Research, Condition, and Disease Categorization categorical spending data.

^b See [Appendix B](#) for definitions of institute/center acronyms.

^c The National Center for Advancing Translational Sciences (NCATS), National Institute of Biomedical Imaging and Bioengineering (NIBIB), and National Library of Medicine (NLM) did not provide written summaries about their respective nutrition research directions for this report.

^d The NIH Office of the Director (OD) includes the Office of Behavioral and Social Sciences Research, Office of Dietary Supplements, Office of Disease Prevention, Office of Extramural Research, Office of Research Infrastructure Programs, Office of Research on Women's Health, and Office of Strategic Coordination—Common Fund for the purposes of this table.

Table 3. NIH Nutrition Research Funding in Current Dollars as a Percentage of Total Institute/Center (IC) Obligations and Number of Projects by NIH Component, Fiscal Year 2021 (in thousands of dollars)

Institute/Center ^a	Research Projects ^b	Nutrition Research and Training ^b	Actual Total IC Obligations ^c	Nutrition as a Percentage of Total IC Obligations
FIC	18	\$2,406	\$83,752	2.87
NCATS	10	\$4,089	\$852,792	0.48
NCCIH	89	\$21,449	\$153,601	13.96
NCI	376	\$154,938	\$6,558,695	2.36
NEI	40	\$18,673	\$832,967	2.24
NHGRI	8	\$10,409	\$614,131	1.69
NHLBI	530	\$251,887	\$3,653,569	6.89
NIA	325	\$192,905	\$3,888,190	4.96
NIAAA	67	\$24,810	\$553,201	4.48
NIAID	236	\$105,299	\$6,049,416	1.74
NIAMS	58	\$18,057	\$632,353	2.86
NIBIB	8	\$2,640	\$409,461	0.64
NICHD	317	\$115,080	\$1,588,125	7.25
NIDA	35	\$14,517	\$1,475,805	0.98
NIDCD	74	\$23,983	\$496,574	4.83
NIDCR	38	\$13,816	\$483,360	2.86
NIDDK	1,720	\$703,872	\$2,229,148	31.58
NIEHS	174	\$77,417	\$893,521	8.66
NIGMS	255	\$77,721	\$2,986,188	2.60
NIMH	79	\$31,776	\$2,100,178	1.51
NIMHD	101	\$44,085	\$389,453	11.32
NINDS	84	\$31,499	\$2,490,566	1.26
NINR	53	\$20,175	\$174,407	11.57
NLM	4	\$1,400	\$460,083	0.30
OD	37	\$102,133	\$2,688,544	3.80
Total	4,736	\$2,065,036	\$42,732,079	4.8

^a See [Appendix B](#) for definitions of institute/center acronyms.

^b Source: NIH RePORT.

^c Source: [NIH Budget Office Actual Total Obligations by Institute and Center FY00–FY21](#).

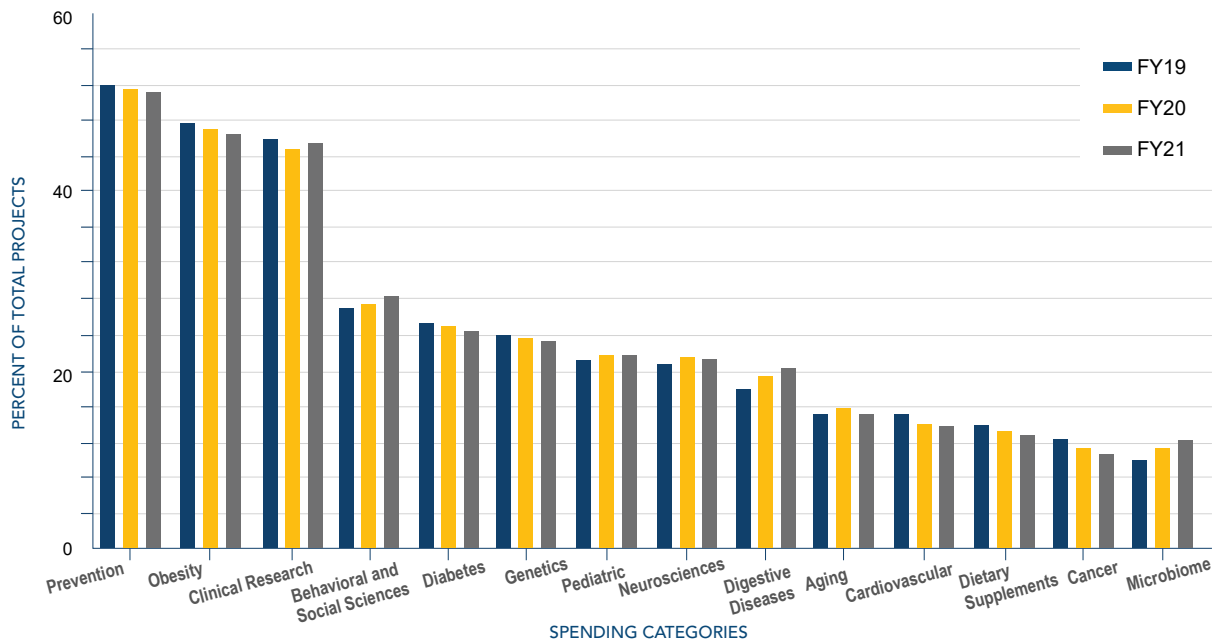
SPENDING CATEGORIES

NIH research projects may meet the criteria of multiple fingerprints, and most nutrition projects are categorized under other spending categories, as well as nutrition.

Figure 1 shows the spending categories that appear most frequently in projects categorized as nutrition. Approximately

half of the nutrition projects funded in FY19–FY21 also were categorized as prevention, and nearly half were categorized as obesity or clinical research.

Figure 1. Overlapping Spending Categories as a Percentage of Total Projects, Fiscal Years 2019–2021 (FY19–FY21)



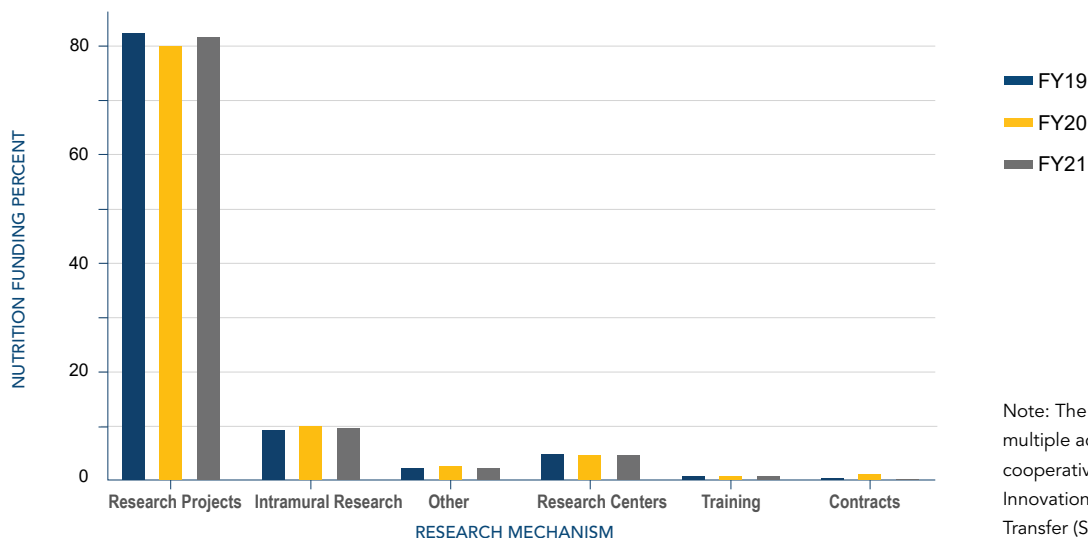
FUNDING MECHANISM

Figure 2 shows the percentage of FY19–FY21 nutrition funding by research mechanism. Extramural and intramural projects comprised 90 percent of the NIH nutrition research portfolio in FY21. Within the extramural category, research project grants comprised the largest category of support.

NIH supports training in biomedical and behavioral nutrition research primarily through two extramural mechanisms: institutional awards and individual awards. The institutional

awards, commonly called “training grants,” are designed to enable institutions to offer training awards to individuals they select for predoctoral and postdoctoral research training. The predoctoral and postdoctoral individual awards are offered as fellowships or career awards to provide research training to individuals to broaden their scientific background and extend their potential for conducting research.

Figure 2. Nutrition Funding Percentages by NIH Research Mechanism, Fiscal Years 2019–2021 (FY19–FY21)



Note: The “Other” research mechanism includes multiple activities, including interagency or cooperative agreements, and Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR).

V. NIH Nutrition Research News

NIH-supported nutrition research led to important discoveries in FY20 and FY21. Many of these discoveries were announced in an *NIH News Release* or published in *NIH Research Matters*. The list below includes a sample of research highlights; a more comprehensive list of NIH nutrition-related press releases and *NIH Research Matters* articles can be found in **Table 4**.

HIGHLIGHTS FROM NIH NEWS RELEASES AND NIH RESEARCH MATTERS

Cancer Treatment

For patients with cancers that do not respond to immunotherapy drugs, adjusting the composition of microorganisms in the intestines—known as the gut microbiome—using stool or fecal transplants may help some of these individuals respond to the immunotherapy drugs, a new study suggests. In an NCI-supported study, some patients with advanced melanoma who initially did not respond to treatment with an immune checkpoint inhibitor, a type of immunotherapy, did respond to the drug after receiving a transplant of fecal microbiota from a patient who had responded to the drug. [Read more.](#)

Diet and Exercise

An NIDDK-supported study found that mice with high blood sugar levels had lower gains from aerobic exercise than normal mice. These results suggest that diet changes may be needed to help people get the most benefit from aerobic exercise. [Read more.](#)

Infectious Diseases

Scientists studying the body’s natural defenses against bacterial infection have identified a nutrient—taurine—that helps the gut recall prior infections and kill invading bacteria. The NIH study found that taurine given to mice as a supplement in drinking water also prepared the microbiota to prevent infection. [Read more.](#)

Table 4. Selected Nutrition-Related NIH News in 2020–2021 in Reverse Chronological Order

Date	Title
12/23/2021	A high-fiber diet may improve the response of melanoma patients to immunotherapy
7/1/2021	Consuming a diet with more fish fats, less vegetable oils can reduce migraine headaches
6/2/2021	Healthy diet before and during pregnancy linked to lower risk of complications, NIH study suggests
5/19/2021	Eating habits change only slightly after gestational diabetes diagnosis, NIH study suggests
2/9/2021	Low-fat diet compared to low-carb diet
2/4/2021	Fecal microbiota transplants help patients with advanced melanoma respond to immunotherapy
1/21/2021	NIH study compares low-fat, plant-based diet to low-carb, animal-based diet
1/15/2021	NIH scientists identify nutrient that helps prevent bacterial infection
11/5/2020	NIH researchers identify gene in mice that controls food cravings, desire to exercise
8/4/2020	High blood sugar may blunt benefits of aerobic exercise
6/17/2020	Gut bacteria may modify behavior in worms, influencing eating habits
5/14/2020	Repurposed drug helps obese mice lose weight, improve metabolic function
4/14/2020	Diet may help preserve cognitive function
4/7/2020	Diets improve but remain poor for most U.S. children

VI. NIH-Sponsored Nutrition Conferences, Seminars, Videocasts, Webinars, Workshops, and Other Educational Opportunities

NIH-supported conferences, seminars, videocasts, webinars, workshops, and other educational opportunities play a key role in the advancement of nutrition science. These forums provide an opportunity to share information and identify research gaps and scientific priorities, as well as stimulate new areas for research. **Table 5** lists relevant nutrition-related events that were sponsored or co-sponsored by NIH ICs in FY20 and FY21. Each of the events in this table are accompanied by a link to access more information about the meeting, including the agenda, video recording, or publications that resulted from the discussions that took place at the event.

Table 5. NIH-Sponsored Nutrition Conferences, Seminars, Videocasts, Webinars, Workshops, and Other Educational Opportunities in Reverse Chronological Order

Title	Event Type	Date	Additional Information
Food Insecurity, Neighborhood Food Environment, and Nutrition Health Disparities: State of the Science Workshop	Scientific Workshop	9/21/2021–9/23/2021	Workshop Webpage Executive Summary
John Milner Nutrition and Cancer Prevention Research Practicum	Educational Opportunity	3/9/2021–3/11/2021	Virtual Event Webpage
Office of Dietary Supplements (ODS) 25th Anniversary Scientific Symposium	Scientific Symposium	10/25 2021–10/26/2021	Symposium Webpage
Precision Nutrition: Research Gaps and Opportunities Workshop	Scientific Workshop	1/11/2021–1/12/2021	Workshop Webpage
Building Unifying Systems of Care Addressing Comorbidities in Women and Girls	NIH Videocast	12/16/2021–12/17/2021	Day 1: NIH Videocast Recording Day 2: NIH Videocast Recording
National Heart, Lung, and Blood Institute Obesity, Nutrition and Physical Activity Seminar: The Role of Teaching Kitchens in Addressing Nutritional Disparities and Implementation Research	NIH Videocast	12/14/2021	NIH Videocast Recording
Strengths, Weaknesses, and Reproducibility in Nutritional Randomized Clinical Trials and Epidemiological Studies	Webinar	12/10/2021	Webinar Webpage

Title	Event Type	Date	Additional Information
Supplement Use Among Hispanics/Latinx Living in the United States: Evidence from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) and Other Cohort Studies	ODS Seminar Series	12/8/2021	ODS Seminars, Conferences, and Workshops Webpage
NIH Rural Health Seminar: Structural-Level Determinants of Rural Health Disparities	NIH Videocast	11/18/2021	NIH Videocast Recording
A Guide to Designing Studies of Diet–Microbiome Interactions	ODS Seminar Series	11/17/2021	ODS Seminars, Conferences, and Workshops Webpage
Post-COVID-19 Syndrome Shared Medical Appointments: Nutrition and Lifestyle Impact Health	NIH Videocast	10/27/2021	NIH Videocast Recording
Getting the Whole Picture—New Methods for Capturing Food, Beverage, and Supplements	ODS Seminar Series	10/6/2021	ODS Seminars, Conferences, and Workshops Webpage
Methodological Approaches for Whole Person Research	NIH Videocast	9/29/2021–9/30/2021	Day 1: NIH Videocast Recording Day 2: NIH Videocast Recording
Exploring the Science Surrounding the Safe Use of Bioactive Ingredients in Infant Formula: Considerations for an Assessment Framework	NIH Videocast	9/23/2021–9/24/2021	Day 1: NIH Videocast Recording Day 2: NIH Videocast Recording
Immune-Boosting Noise: Supplements and Misinformation in Pop Culture	ODS Seminar Series	9/15/2021	ODS Seminars, Conferences, and Workshops Webpage
NIH Obesity Research Task Force (ORTF) Seminar Series: Obesity and COVID-19	Seminar Series	9/10/2020	ORTF Obesity-Related Meetings and Workshops
Dietary Supplement Use by Breast Cancer Patients	ODS Seminar Series	5/12/2021	ODS Seminars, Conferences, and Workshops Webpage
Gut Microbiome and Personalized Nutrition	ODS Seminar Series	4/14/2021	ODS Seminars, Conferences, and Workshops Webpage
Plant Flavonoids and Human Health	ODS Seminar Series	3/10/2021	ODS Seminars, Conferences, and Workshops Webpage

Title	Event Type	Date	Additional Information
Uric Acid Metabolism and Purines in Diet and Dietary Supplements	ODS Seminar Series	2/17/2021	ODS Seminars, Conferences, and Workshops Webpage
Breastmilk Ecology: Genesis of Infant Nutrition (BEGIN) Meeting Series: Working Group 2: Human Milk Composition	NIH Videocast	1/29/2021	NIH Videocast Recording
Vitamin D and Chronic Disease	ODS Seminar Series	1/27/2021	ODS Seminars, Conferences, and Workshops Webpage
Breastmilk Ecology: Genesis of Infant Nutrition (BEGIN) Meeting Series: Working Group 3: Infant Inputs	NIH Videocast	1/22/2021	NIH Videocast Recording
Breastmilk Ecology: Genesis of Infant Nutrition (BEGIN) Meeting Series—Working Group 1: Maternal Inputs	NIH Videocast	1/15/2021	NIH Videocast Recording
Curcumin Effects on Behavioral Resilience	ODS Seminar Series	1/13/2021	ODS Seminars, Conferences, and Workshops Webpage
Metabolism-Based Therapies for Epilepsy Virtual Workshop	Scientific Workshop	11/9/2020	Workshop Webpage
Automated Self-Administered 24-Hour (ASA24) Dietary Assessment Tool: Recent Updates and Future Enhancements	Webinar	9/14/2020	Video
NIH Obesity Research Task Force (ORTF) Seminar Series: Obesity and Women’s Health Virtual Symposium	Seminar Series	9/10/2020	ORTF Obesity-Related Meetings and Workshops
Conflicting and Controversial Health Information in the Media: Content, Exposure, and Effects	ODS Seminar Series	5/27/2020	ODS Seminars, Conferences, and Workshops Webpage
Beta-Glucan Degradation Shapes the Structure and Function of Gut Microbiota and Impacts Host Health	ODS Seminar Series	3/11/2020	ODS Seminars, Conferences, and Workshops Webpage
Ascorbic Acid Physiology and Pharmacokinetics: Pathways to Prevention of Diabetic Microvascular Disease	ODS Seminar Series	2/19/2020	ODS Seminars, Conferences, and Workshops Webpage

VII. Nutrition Practicums

Several ICs offer practicums with the goal of expanding specific research interests. Both NCI and the [NIH Office of Dietary Supplements \(ODS\)](#) offer annual nutrition-related research practicums. These practicums are open to the public at no charge but require an application.

JOHN MILNER NUTRITION AND CANCER PREVENTION RESEARCH PRACTICUM

NIH and the U.S. Department of Agriculture (USDA) offer a one-week educational opportunity in nutrition and cancer prevention research, the [John Milner Nutrition and Cancer Prevention Research Practicum](#), for individuals with a sustained commitment to nutrition and health promotion.

Offered since 2004, this intense learning session provides specialized instruction on the role of diet and bioactive food components as modifiers of cancer incidence and tumor behavior and engages participants through didactic and interactive experiences. The practicum is not intended to enhance patient education or clinical practice; rather, it is research-based and best suited for those interested in expanding their research.

The practicum is open—at no cost—to graduate students; registered dietitian nutritionists; students enrolled in an Accreditation Council for Education in Nutrition and Dietetics–accredited, supervised-practice program or combined with graduate studies; and nongovernment academicians, physicians, and other health care professionals in the early stage of their career. Preference is given to individuals with relevant experience in nutrition and cancer research. International applicants are welcome. Those who have previously participated in the practicum are not eligible. A full-week commitment from the participant is required.

MARY FRANCES PICCIANO DIETARY SUPPLEMENT RESEARCH PRACTICUM

The [Mary Frances Picciano Dietary Supplement Research Practicum](#) is an annual two-and-a-half-day educational opportunity offered by the ODS that provides fundamental knowledge of dietary supplements. This intensive practicum provides a thorough overview and foundation of issues, concepts, unknowns, and controversies about dietary supplements and supplement ingredients. It also emphasizes the importance of scientific investigations to evaluate the efficacy, safety, and value of these products for health promotion and disease prevention, as well as how to conduct this type of research.

This practicum is open—at no cost—to selected faculty, graduate students, and research practitioners in such health-related disciplines as nutrition, food science, pharmacy, pharmacology and pharmacognosy, exercise science and kinesiology, medicine, dentistry, nursing, and complementary and alternative medicine. Preference will be given to candidates who are full-time academic faculty, research practitioners, doctoral students, postdoctoral students, and fellows. Applications also will be accepted from health care providers and scientists with a master's degree or higher whose work involves research with dietary supplements, master's-level students, and students in allied health schools. The practicum is limited to approximately 100 attendees per session.

VIII. Nutrition-Related NIH-Wide Committees and Working Groups

Several groups are engaged in collaborative nutrition-related activities at NIH. These activities facilitate the sharing of resources and expertise, and they foster communication and opportunities for collaboration within the NIH nutrition science community. Key groups with representation from across NIH are listed and described below.

STRATEGIC PLAN FOR NIH NUTRITION RESEARCH IMPLEMENTATION WORKING GROUPS

The NIH Nutrition Research Implementation Working Groups (IWGs) are assisting ONR and NIH in implementing the

[2020–2030 Strategic Plan for NIH Nutrition Research](#) and are organized around the following topic areas.

Foundational Nutrition Science

This working group focuses on basic, translational, and methodological foundational research in nutrition science. Recent topics of discussion include bioinformatic gaps in nutrition-related pathways, genes (e.g., transporter genes),

and metabolites; meal-timing strategies for improving health, including circadian influences on nutrition and health; and the influence of nutrition on immune function.

Nutrition and Health Disparities

This working group seeks to advance NIH research to better understand the interactions between diet, nutritional status, the environment, and biological and behavioral processes, and how they contribute to health disparities. It will also encourage research on how to prevent and treat nutrition-related diseases and reduce health inequities. Because “nutrition and health disparities” is a cross-cutting theme of the Strategic Plan for

Nutrition Research, the working group will collaborate with the other IWGs to support nutrition and health disparities research. These activities will stimulate the development of research priorities that elucidate how diversity of all kinds—race, ethnicity, socioeconomic status, disability, sex, gender, gender identity, and geography—influences nutrition and health interrelationships.

Microbiome, Diet, and Health Interrelationships

The main goal of this working group is to coordinate and promote research on diet-microbiome host interactions. This working group is represented by intramural and extramural NIH scientists with interest in microbiome–host interactions across the lifespan and in relation to disease and treatment. This group aspires to advance a precision

nutrition research agenda by better defining diet–microbiome host interrelationships, and by aligning with the trans-NIH microbiome working group and fostering collaborative interactions. Some of the planned activities for the group include facilitating funding initiatives, organizing workshops and seminar series, and performing grant portfolio analysis.

Nutrition Across the Lifespan

This working group will advance research to define the role of nutrition to optimize health and prevent disease across the lifespan. The group comprises program staff from multiple NIH ICOs with expertise in the impact of nutrition on health, development, and disease from the periconceptional and prenatal timepoints to old age. Recognizing that each phase across the lifespan has unique research needs (i.e., pregnancy, infancy and early toddlerhood, adolescence, young and

middle-aged adults, and older adulthood), the group will promote research on understudied time windows as well as research to better understand how nutritional needs and eating behaviors change throughout the lifespan to provide an evidence base for dietary intake recommendations to promote appropriate growth and development, health, disease prevention, and improved disease outcomes.

Implementation of Nutrition-Related Programs, Practices, and Behaviors

This working group seeks to advance the reach of effective nutrition and diet-related behavior interventions through implementation and dissemination science. The working group will promote initiation and sustainability of healthy eating behaviors by emphasizing multilevel (e.g., policy, community,

family, and individual) approaches to bring precision nutrition interventions to scale through innovative research methods. Additional focus will be placed on extending research and practice capacity and evaluation of policies and programs to improve dietary quality.

Approaches, Methods, and Tools for Dietary Intake Assessment

Achieving the goal of precision nutrition hinges on changing the way people think about diet, toward a holistic view that considers and analyzes dietary patterns, rather than individual nutrients. This working group seeks to advance the science of dietary assessment, with a goal of developing accurate, user-friendly, and customizable dietary intake data-capture tools.

These approaches include mobile devices, as well as innovative biomarkers of dietary intake and exposure. Additional priorities include strategies to combine data from multiple methods of dietary-intake assessment; integrate data sets with nutrient-composition databases; and develop and disseminate statistical approaches to mitigate the effect of measurement error.

Medical Nutrition

This working group will focus on research aimed at expanding knowledge about the role of nutrition in disease treatment to address how the use of “Food is Medicine” can be improved in clinical settings. The ultimate goal is to enhance the ability

of clinicians and the public to have evidence-based “medical foods,” medical nutrition therapy, or specific eating patterns that may help to prevent or reverse chronic diseases or to improve the effectiveness of medical treatments.

STRATEGIC PLAN FOR NIH NUTRITION RESEARCH: COMMITTEE SUPPORT

The NIH Nutrition Research Report received additional input and support from the following NIH-wide committees.

Nutrition Research Coordinating Committee

The NIH [Nutrition Research Coordinating Committee \(NRCC\)](#) was established in 1975 for the primary purpose of reviewing, discussing, and stimulating support for nutrition research and training within NIH. Today, the NRCC is a vibrant group whose membership includes representatives and interested staff from NIH ICs and other federal agencies. The NRCC is chaired by the ONR Director. NRCC meetings occur monthly and typically

include scientific seminars, nutrition research program and policy updates, information about research interests, and collaborative project activities. Additionally, a subcommittee of the NRCC, the [NIH Nutrition Education Subcommittee](#), reviews federal nutrition education materials that contain dietary guidance for the general population.

Obesity Research Task Force

The NIH [Obesity Research Task Force \(ORTF\)](#) was formed to provide the research community a platform to exchange information on a broad spectrum of NIH-sponsored obesity-related research, including molecular, genetic, behavioral, environmental, clinical, and epidemiologic studies. The ORTF is

co-chaired by the Directors of NIDDK; the National Heart, Lung, and Blood Institute (NHLBI); and the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD). Members of the ORTF include representatives from these and many other NIH institutes and centers.

Coordinating Committee on Research on Women's Health

NIH IC Directors or their designees comprise the NIH Coordinating Committee on Research on Women's Health (CCRWH). As established by legislative mandate in the NIH Revitalization Act of 1993, [CCRWH members](#) serve as direct liaisons between the NIH Office of Research on Women's Health (ORWH) and NIH ICs. The CCRWH provides valuable guidance, collaboration, and support to ORWH program goals, including ORWH's career development programs and outreach efforts.

Specific CCRWH support involves—

- ▶ Serving as a resource for women's health activities across the NIH
- ▶ Supporting methods to gather data by age and ethnic/racial groups of women's participation in clinical trials
- ▶ Supporting the development and expansion of clinical trials necessary to the health of women
- ▶ Encouraging and supporting research on women's health
- ▶ Identifying needs regarding the coordination of research activities, including intramural and extramural multidisciplinary activities

HIV/AIDS Executive Committee

The [NIH HIV/AIDS Executive Committee \(NAEC\)](#) is the coordinating committee for all NIH HIV/AIDS research and provides recommendations to the Director of the Office of AIDS Research (OAR) regarding the development and implementation of HIV/AIDS research programs and funding priorities in accordance with the [NIH Strategic Plan for HIV](#)

[and HIV-Related Research](#). The NAEC also facilitates inter and intra-agency communication among the OAR and ICO to coordinate program initiatives and assists in the development of NIH-wide HIV/AIDS research plans, policies, and procedures. NAEC membership primarily includes a designated HIV/AIDS Coordinator from each ICO with an HIV/AIDS research budget.

Prevention Research Coordinating Committee

The [Prevention Research Coordinating Committee \(PRCC\)](#) is an NIH-wide committee that provides a forum for NIH ICs and other federal partners to exchange programmatic and scientific information on prevention research activities that are sponsored by federal agencies and other organizations.

The NIH Office of Disease Prevention (ODP) coordinates the Committee's activities. The PRCC advises the ODP Director and provides recommendations regarding scientific, programmatic, and policy issues related to health promotion and disease prevention.

Trans-NIH Microbiome Working Group

The [Trans-NIH Microbiome Working Group \(TMWG\)](#) was established in 2012 to provide a forum for coordinating NIH extramural research activities related to the human microbiome. TMWG membership is open to all extramural program staff from ICs with an interest in the human microbiome. TMWG meetings occur monthly.

IX. Key Federal Collaborations

Interagency collaboration enhances the field of nutrition. Highlighted below are ongoing collaborative efforts.

DIETARY GUIDELINES FOR AMERICANS

The *Dietary Guidelines for Americans* are the foundation of federal food and nutrition programs, policies, and education initiatives. The *Dietary Guidelines* are jointly issued by the U.S. Department of Agriculture (USDA) and the U.S. Department of Health and Human Services (HHS) every 5 years, as required by law. The Dietary Guidelines are informed by a scientific report prepared by a federal advisory committee and comments received from federal agencies, industry, organizations, and consumers. The most current version is the [2020–2025 Dietary Guidelines for Americans](#).

USDA and HHS identified topics and scientific questions to be examined by the 2020 Dietary Guidelines Advisory Committee prior to establishing the Committee. The Departments added

this step to promote a deliberate and transparent process, respond to feedback on the *Dietary Guidelines* development process, identify expertise needed on the Committee, help manage resources, and ensure the scientific review conducted by the Committee addresses federal nutrition policy and program needs.

USDA and HHS requested public nominations to the 2020 Dietary Guidelines Advisory Committee from September 6 to October 6, 2018. Twenty nationally recognized scientists were appointed to serve on the Committee in February 2019. The Committee's work ended with the release of its scientific report to the secretaries of USDA and HHS. The two agencies then worked together to develop the *2020–2025 Dietary Guidelines*.

DIETARY REFERENCE INTAKES

[Dietary Reference Intakes \(DRIs\)](#) are nutrient reference values developed by the National Academies of Sciences, Engineering, and Medicine (NASEM). The DRIs are intended to serve as a guide for nutritional intake and provide the scientific basis for the development of food guidelines in the United States and Canada. These nutrient reference values are specified based on age, gender, and life stage and cover more than 40 nutrient substances.

Government coordination of DRI-related activities is a joint effort between representatives of the U.S. and Canadian

governments. The U.S.–Canada Joint DRI Working Group and the Interagency Committee on Human Nutrition Research (ICHNR) Subcommittee on Dietary Reference Intakes work together to develop an efficient process that ensures DRI values continue to be scientifically sound, current, and useful for public health purposes. This includes identifying DRI needs and prioritizing nutrient reviews, advancing work to resolve methodology issues, and coordinating funding for new DRI reviews.

DIETARY SUPPLEMENT INGREDIENT DATABASE

The [Dietary Supplements Ingredient Database \(DSID\)](#) contains analytical data on dietary supplement product ingredients. The DSID was developed by the [USDA Methods and Application of Food Composition Laboratory](#) in collaboration with the NIH ODS and other federal agencies. The goals of the DSID project are to establish reliable, analytically predicted estimates of

ingredient content in dietary supplement products; compare analyzed levels of ingredients to labeled values provided by manufacturers, if available; and improve dietary intake assessments by providing data files and online calculators that adjust label values into analytically predicted amounts.

DIETARY SUPPLEMENT LABEL DATABASE

The [Dietary Supplement Label Database \(DSLDB\)](#) is a joint effort between the National Library of Medicine and ODS, with input from many federal stakeholders. The database contains the full

label contents from a sample of dietary supplement products marketed in the United States with a web-based user interface that provides access to label information.

FEDERAL DATA CONSORTIUM ON PREGNANCY AND BIRTH TO 24 MONTHS

The Federal Data Consortium (Data Consortium) on Pregnancy and Birth to 24 Months (P/B-24) is a federal forum for sharing information and finding solutions to resolve crucial needs for data on P/B-24 populations to inform public health initiatives.

The Data Consortium facilitates the ability of federal agencies to gather and review input to inform projects and research plans and share information on data availability and usage. More than a dozen federal agencies have funded projects

coordinated by the Data Consortium that are focused on filling critical gaps in scientific knowledge to support evidence-based programs, policies, and educational initiatives across the government and non-government sectors. The collaboration spans 185 federal staff and leaders from 30 agencies in five departments: HHS, USDA, the U.S. Agency for International Development (USAID), U.S. Department of Defense (DoD), and U.S. Environmental Protection Agency (EPA). The Data Consortium is co-led by representatives of NIH, the Centers for Disease Control and Prevention (CDC), HHS Office of Disease Prevention and Health Promotion (ODPHP), U.S. Food and Drug Administration (FDA), USDA Agricultural Research Service (ARS), and USDA Food and Nutrition Service.

FEDERAL WORKING GROUP ON DIETARY SUPPLEMENTS

The [Federal Working Group on Dietary Supplements \(FWGoDS\)](#) is led by the ODS and includes representatives from other NIH ICOs and other federal agencies. The FWGoDS provides an opportunity to strengthen collaborative efforts and to share information and discuss issues, initiatives, and research related

The Data Consortium resulted from efforts by ODPHP within the Office of the Assistant Secretary for Health in 2016 to coordinate “special studies” from CDC’s National Health and Nutrition Examination Survey (NHANES) to fill crucial needs for data on P/B-24 populations to support future *Dietary Guidelines for Americans*. These data go beyond the needs of the Dietary Guidelines. Initiatives include The Human Milk Composition Initiative and B-24 questionnaire content in the NHANES Diet and Behavior Questionnaire.

to dietary supplements. The FWGoDS was established, in part, in response to a congressional mandate that ODS serve as an advisor to federal health agencies on issues related to dietary supplements. The FWDoDS has met twice a year since 2005.

FDA–NIH JOINT AGENCY ON NUTRITION WORKING GROUP

The FDA–NIH Joint Agency on Nutrition Working Group, a subgroup of the NIH–FDA Joint Leadership Council, was formed in 2016 to facilitate high-quality nutrition research to improve public health outcomes across the lifespan to reduce the risk

factors for and incidence of nutrition-related chronic disease and inform nutrition-related regulatory decision-making and consumer outreach and education related to nutrition.

HEALTHY PEOPLE

Healthy People is a national health promotion and disease prevention agenda that provides a framework to achieve 10-year goals and objectives to improve the nation’s health. The Healthy People initiative, which began more than 30 years ago, is grounded in the principle that setting national objectives and monitoring progress toward achieving them can motivate action.

Healthy People objectives are organized within distinct topic areas, for which multiple agencies provide leadership. NIH co-leads many of the topic areas, including the Nutrition and Weight Status Topic Area. For more information about objectives that monitor access to healthier foods, weight

reduction and nutritional counseling in health care and worksite settings, weight status, food insecurity, food and nutrient consumption, and iron deficiency, view the [Healthy People 2020 Midcourse Review for Nutrition and Weight Status](#).

In 2020, a new set of science-based, 10-year national objectives—*Healthy People 2030*—was launched with the goal of improving the health of all Americans by 2030. The development of *Healthy People 2030* included the establishment of a [framework](#) for the initiative—including the vision, mission, foundational principles, plan of action, and overarching goals—and identifying new objectives.

INTERAGENCY COMMITTEE ON HUMAN NUTRITION RESEARCH

The [Interagency Committee on Human Nutrition Research \(ICHNR\)](#) aims to increase the overall effectiveness and productivity of federally supported or conducted human nutrition research. Established in 1983 and reassembled in 2013, the ICHNR is charged with improving planning, coordination, and communication among federal agencies engaged in nutrition research and facilitating the development

and updating of plans for federal research programs to meet current and future domestic and international needs for nutrition. ICHNR includes representatives from HHS, DoD, EPA, USAID, USDA, the U.S. Department of Commerce, Federal Trade Commission, National Aeronautics and Space Administration, National Science Foundation, Veterans Health Administration, and the White House Office of Science and

Technology Policy. In addition to its interagency coordination and communication roles, ICHNR strives to increase the effectiveness and productivity of federal agencies that are engaged in nutrition research by supporting activities to

inform researchers and policy staff on ongoing federally supported or conducted human nutrition research, nutrition monitoring, and nutrition program activities.

NATIONAL COLLABORATIVE ON CHILDHOOD OBESITY RESEARCH

The [National Collaborative on Childhood Obesity Research \(NCCOR\)](#) is a public-private partnership undertaken by CDC, USDA, the Robert Wood Johnson Foundation, and four NIH ICs—NCI, NICHD, NIDDK, NHLBI, and the Office of Behavioral and Social Sciences Research (OBSSR). The initiative was launched in 2009 with a primary mission of improving the efficiency, effectiveness, and application of childhood obesity research and halting and reversing the childhood obesity epidemic through enhanced coordination and collaboration. The NCCOR partnership has focused its efforts on identifying, designing, and implementing innovative, practical, and sustainable interventions in diverse settings; increasing national, state, and local obesity surveillance activities; supporting childhood obesity research and program evaluation activities; and identifying ways to optimize research outcomes, build capacity for new research

and surveillance, and create and support the mechanisms and infrastructure needed for research translation and dissemination. These efforts have proven enormously successful. NCCOR partners have formed strategic alliances with diverse groups, produced education and training resources for researchers and stakeholders, and informed the broader research community and policymakers of progress in child obesity prevention.

The [2020 NCCOR Annual Report](#) and [2021 NCCOR Annual Report](#) are available on the NCCOR website. NCCOR provides a variety of unique tools that may be of key interest to researchers. These include a [Measures Registry](#), four [Measures Registry User Guides](#), [Measures Registry Learning Modules](#), a [Catalogue of Surveillance Systems](#), a [Registry of Studies](#), and a [Youth Compendium of Physical Activities](#).

NATIONAL FOOD AND NUTRIENT ANALYSIS PROGRAM

Federal food and dietary supplement product database activities have been coordinated through the [National Food and Nutrient Analysis Program \(NFNAP\)](#) initiative since 1997. NFNAP is directed by the USDA ARS' Methods and Application of Food Composition Laboratory (newly formed from a consolidation of the Nutrient Data Laboratory and the Food Composition and Methods Development Laboratory) in collaboration with NCI and ODS, along with other NIH ICs and the FDA.

The five specific aims of NFNAP are to (1) institute a monitoring program for key foods and critical nutrients (to date, approximately 1,400 foods have been sampled and analyzed); (2) conduct comprehensive analyses of selected key foods; (3) develop databases for high-priority foods consumed by U.S. ethnic subpopulations; (4) develop databases for new

bioactive components; and (5) develop a validated database for ingredients in dietary supplements. For each specific aim, the process includes the identification of foods for analysis, development of unique statistically based sampling plans, and application of validated analytical chemistry. The primary outcome of the initiative is to develop comprehensive nutrient composition databases that have unprecedented analytical quality.

Several recent accomplishments in food composition analysis and database development can be traced to the NFNAP initiative. A review of the past two decades of collaboration can be found on [PubMed.gov](#). The NFNAP initiative also has supported dietary supplements research and database development—including the DSID, which stemmed from the NFNAP initiative—and the DSLD. Both are described above.

X. NIH Institute, Center, and Office Research Directions

NIH supports extensive research on the relationship between nutrition and health. Through approaches that focus on both basic and translational research, as well as training investigators, the NIH nutrition portfolio covers a vast array of programs. Details about the specific research directions and priority nutrition areas of each institute, center, and office are in this section.

[Clinical Center](#)

[Fogarty International Center \(FIC\)](#)

[National Cancer Institute \(NCI\)](#)

[National Center for Complementary and Integrative Health \(NCCIH\)](#)

[National Eye Institute \(NEI\)](#)

[National Heart, Lung, and Blood Institute \(NHLBI\)](#)

[National Human Genome Research Institute \(NHGRI\)](#)

[National Institute on Aging \(NIA\)](#)

[National Institute on Alcohol Abuse and Alcoholism \(NIAAA\)](#)

[National Institute of Allergy and Infectious Diseases \(NIAID\)](#)

[National Institute of Arthritis and Musculoskeletal and Skin Diseases \(NIAMS\)](#)

[Eunice Kennedy Shriver National Institute of Child Health and Human Development \(NICHD\)](#)

[National Institute on Deafness and Other Communication Disorders \(NIDCD\)](#)

[National Institute of Dental and Craniofacial Research \(NIDCR\)](#)

[National Institute of Diabetes and Digestive and Kidney Diseases \(NIDDK\)](#)

[National Institute of Drug Abuse \(NIDA\)](#)

[National Institute of Environmental Health Sciences \(NIEHS\)](#)

[National Institute of General Medical Sciences \(NIGMS\)](#)

[National Institute of Mental Health \(NIMH\)](#)

[National Institute on Minority Health and Health Disparities \(NIMHD\)](#)

[National Institute of Neurological Disorders and Stroke \(NINDS\)](#)

[National Institute of Nursing Research \(NINR\)](#)

[Office of Dietary Supplements \(ODS\)](#)

CLINICAL CENTER

<https://clinicalcenter.nih.gov>

OVERVIEW

The Clinical Center at NIH in Bethesda, Maryland, is part of NIH's intramural science research program and is the nation's largest hospital devoted entirely to clinical research. It is a national resource that makes it possible to rapidly translate scientific observations and laboratory discoveries into new approaches for diagnosing, treating, and preventing disease. Currently, about 1,600 clinical research studies are in progress at the NIH Clinical Center. The clinical trials at the NIH Clinical Center are predominantly Phase I and Phase II, and they often are first-in-human studies to test safety and efficacy.

More than 500,000 patients, from all 50 states and throughout the world, have participated in clinical research at the Clinical Center since it opened in 1953.

The Clinical Center promotes translational research—that is, the transfer of scientific laboratory research into applications that benefit patient health and medical care. The “bench-to-bedside” approach adopted in 1953 locates patient care units in close proximity to cutting-edge laboratories conducting related research. This facilitates interaction and collaboration among clinicians and researchers. Most importantly, patients and families in the Clinical Center benefit from the cutting-edge technologies and research and the compassionate care that are the signature of NIH.

The Mark O. Hatfield Clinical Research Center was opened in 2005. The facility houses inpatient units, day hospitals, and research laboratories and connects to the original Warren Grant Magnuson Clinical Center. Together, the Magnuson and Hatfield buildings form the NIH Clinical Center. They serve the dual role of providing humane and healing patient care and the environment clinical researchers need to advance clinical science. It was named in honor of Senator Mark O. Hatfield of Oregon, who supported medical research throughout his congressional career.

The 870,000-square-foot Hatfield building has 200 inpatient beds and 93 day-hospital stations. This arrangement can be easily adapted to allow more inpatient beds and fewer day-hospital stations, or vice versa, because the facility's design is highly flexible.

NUTRITION RESEARCH SERVICES

Clinical Research Dietitians consult with NIH institute and center investigators to plan, design, and implement nutrition-related components of proposed research protocols. Dietitians recommend optimal methodologies to ensure valid and reliable data and assist with data collection, analysis, interpretation, and manuscript preparation. Dietitians also advise on the benefit and appropriateness of adding nutrition services to existing research protocols.

Nutrition research services include—

- ▶ **Research Meals/Diets**

Purpose: to control food and nutrient intake to meet protocol needs. Research meals are prepared in a dedicated kitchen using specialized equipment and software.

- ▶ **Dietary Intake and Eating Behavior Assessments**

Purpose: to quantify energy and nutrient intake for a defined period of time; to characterize eating behaviors. Specialized software and questionnaires are used to analyze food intake.

- ▶ **Body Composition Analysis**

Purpose: to assess lean and fat mass.

- ▶ **Nutrition Counseling**

Purpose: to provide nutrition education and counseling to research subjects as part of protocol requirements

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FOGARTY INTERNATIONAL CENTER

https://www.fic.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$2,406,345
Nutrition as Percentage of Total IC Obligations for FY21	2.6%

OVERVIEW

The Fogarty International Center (FIC) is dedicated to advancing the mission of NIH by supporting and facilitating global health research conducted by U.S. and international investigators, building partnerships between health research institutions in the United States and abroad, and training future generations of scientists to address global health needs. FIC currently funds more than 400 research and training projects involving more than 100 U.S. universities and investigators in numerous foreign countries, most of which are in low- and middle-income countries (LMICs). FIC staff engage with scientists around the world to address critical global health research problems, such as emerging infectious diseases, and highlight the need to strengthen research capacity in LMICs.

FIC has a strong interest in nutrition as it relates to overall global health. Recent nutrition-related research and research training projects funded by FIC aim to do the following:

- ▶ Provide short-, intermediate-, and long-term training to health professionals who are engaged in population-based and clinical and translational noncommunicable disease research focused on bone health and vitamin D supplementation across the lifespan through the Lebanon-based Scholars in HeAlth Research Program (SHARP).¹
- ▶ Train doctoral students and postdoctoral fellows at Makerere University in Uganda in the epidemiology and pathogenesis of infection-related neurocognitive impairment, including the assessment of the interactions of micronutrient deficiency and infection, with the goal of establishing a cohort of Ugandan researchers who can advance the understanding, prevention, and treatment of long-term neurocognitive disability associated with infectious diseases and micronutrient deficiency.²
- ▶ Identify risk factors for suboptimal breastfeeding and opportunities for breastfeeding promotion among working mothers and determine the impact of adopting policies and practices that are supportive of breastfeeding among mothers involved in unskilled manual labor on women's productivity in Kenya.³
- ▶ Develop and test a smartphone application that is designed to adopt a user-centered design approach to support the self-management and treatment of gestational diabetes mellitus among patients in a suburban hospital setting in Nepal and to provide easily understood clinician-level information to aid clinical decision-making and counseling.⁴
- ▶ Build sustainable capacity in pediatric infectious disease, gastroenterology, and nutrition research, specifically as they relate to environmental enteric dysfunction and its complications, including vaccine failure, undernutrition, and subsequent growth failure in children residing in Pakistan.⁵
- ▶ Evaluate changes in adult dietary patterns and cardiometabolic disease risk profiles associated with the construction of the Interoceanic Highway through Peru's Southern Amazon by measuring biomarkers of nutrition transition and complementary dietary survey data.⁶
- ▶ Provide mentored training for Ph.D. and M.Sc. candidates in Kenya, with a focus on improving HIV health outcomes through innovative food security and poverty alleviation interventions.⁷
- ▶ Demonstrate that a seed extract of the plant *Moringa oleifera* can delay the onset of diabetes in a rat model to a greater extent than moderate caloric restriction. The results maintain the extract's previously documented traditional uses, provide evidence of the bioactive role of moringa isothiocyanates, and suggest the efficacy of moringa supplementation for diabetes management in populations at risk for type 2 diabetes mellitus.⁸

¹ Award number: D43TW009118.

² Award number: D43TW010928.

³ Award number: K01TW010827.

⁴ Award number: R21TW011377.

⁵ Award number: D43TW007585.

⁶ Award number: K01TW011478.

⁷ Award number: D43TW011306.

⁸ Award number: K01TW009987.

In addition to the funded research, FIC also led the following nutrition-related global health projects:

- ▶ In the Pakistan Water Sanitation, Health, and Hygiene Intervention study, extensive surveillance of more than 1,800 children under age 5 was conducted from 1989 to 1996, with young-adult follow-up performed 15–20 years later. This research project aims to determine the long-term health impact of early-childhood diarrhea, pneumonia, and nutritional status on later growth and educational development. The researchers found that “childhood undernutrition was related to adolescent height, and thereby weakly to cognitive score, whereas educational opportunities and cultural language group were more strongly associated with human capital than childhood illness was.”⁹
- ▶ The MAL-ED (Malnutrition and Enteric Diseases) project was an international collaboration investigating the effects of enteric pathogens, nutrition, and socioeconomic status on childhood development, including gut physiology, immune function, vaccine response, physical growth, and cognitive development. A prospective observational study of cohorts of neonates followed to age 24 months was conducted at geographically diverse sites in Bangladesh, Brazil, India, Nepal, Pakistan, Peru, South Africa, and Tanzania. A second study followed the cohorts until 5 years of age. Conducted from 2008 to 2019, the multisite project was supported by the Bill & Melinda Gates Foundation. Results from this project currently are being published, with more than 20 articles published between 2020 and 2021.
- ▶ The Childhood Obesity Prevention Across Borders: The Promise of U.S.–Latin American Research Collaboration addresses the multifaceted nature of childhood obesity prevention in Latin America and among Latino populations in the United States. Sharing research strategies and proven methods among researchers from Latin America and the United States, especially those working with U.S. Latino populations, helped identify common ground and lessons learned for the adaptation and implementation of evidence-informed childhood obesity prevention interventions. The subsequent peer-reviewed scientific journal supplement, published in English and Spanish in *Obesity Review*, explores nine crosscutting themes and articulates a shared research agenda to address childhood obesity prevention in Latin America and among Latino populations in the United States.^{10,11}

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⁹ Rasmussen ZA, Shah WH, Hansen CL, Azam SI, Hussain E, Schaefer BA, Zhong N, Jamison AF, Ahmed K, McCormick BJJ; Oshikhandass Water, Sanitation, Health and Hygiene Interventions Project. Examining the relationships between early childhood experiences and adolescent and young adult health status in a resource-limited population: a cohort study. *PLoS Med*. 2021 Sep 28;18(9):e1003745. doi: 10.1371/journal.pmed.1003745.

¹⁰ Perez-Escamilla R, King A, Rivera J. Obesity Prevention Across Borders: The Promise of US-Latin American Research Collaboration. *Obes Rev*. 2021 Jun;22 Suppl 3(Suppl 3):e13238.

¹¹ Perez-Escamilla R, King A, Rivera J. Prevención transfronteriza de la obesidad infantil: la promesa de colaboración entre EE. UU. y Latinoamérica en investigación. *Obes Rev*. 2021 Oct;22 Suppl 5:e13343.

NATIONAL CANCER INSTITUTE

https://www.cancer.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$154,938,472
Nutrition as Percentage of Total IC Obligations for FY21	2.2%

OVERVIEW

Cancer [is the second-leading cause of death](#) in the United States.¹² In 2022, there will be an estimated 1.9 million new cancer cases diagnosed and 609,360 cancer deaths in the United States.¹³ Since the National Cancer Institute (NCI) was established in 1937, scientists have identified various cancer-related factors, such as genetics and environmental exposures. Foods, alcohol, and their associated constituents are thought to be environmental factors that can significantly influence cancer risk and tumor behavior. The complexity of this area is expanded by the thousands of dietary components that are consumed.

Cancer research and training are performed and supported by both intramural and extramural programs at NCI. NCI makes awards to investigators residing in the United States and at international sites. NCI's goal is to support research that ultimately leads to important clinical outcomes: improvements in prevention, diagnosis, treatment, and survivorship that can reduce the incidence, morbidity, and mortality of all types of cancer. NCI requires a wide range of research disciplines that span the continuum from basic science to clinical research to research on implementation and cancer care delivery. Areas of research that NCI supports include basic sciences, such as genetics, genomics, cell biology, immunology, and nanotechnology; translational and clinical sciences, such as drug development and testing, diagnostics, and the discovery and development of molecular markers, advanced imaging technologies, and new radiotherapy techniques; population sciences, such as population genetics, epidemiology, and environmental sciences; and behavioral sciences at biological, psychological, sociocultural, environmental, and policy levels. NCI supports various interdisciplinary and transdisciplinary training programs in basic, clinical, and population sciences to foster the development of future national and international scientific leaders who will use modern approaches and technologies to address critical issues in cancer. NCI provides various dietary assessment research resources, such as dietary collection resources (e.g., Dietary Assessment Primer), data collection tools (e.g., Automated Self-Administered 24-Hour Dietary Recall, Diet History Questionnaire), food composition databases, and dietary analysis tools (e.g., Healthy Eating Index, World Cancer Research Fund/American Institute for Cancer Research Score).

NCI nutrition research incorporates a variety of approaches to determine the influence of diet, dietary patterns, and dietary components on the cancer process, including epidemiologic studies (i.e., cross-sectional, case-control, and cohort studies), clinical intervention studies, compositional studies involving food content and components, preclinical studies (e.g., animal models and cell cultures), clinical studies of biochemical/physiologic assessments of nutrient metabolism and absorption patterns, and studies of diet and lifestyle behaviors. In addition, NCI provides summaries of ongoing research related to nutrition and cancer through websites, such as those listed below, and other programs within the Office of Communications and Public Liaison.

EPIDEMIOLOGY AND GENOMICS RESEARCH PROGRAM

- ▶ [Selected Projects](#)
- ▶ [Dietary Assessment Research Resources](#)

[Automated Self-Administered 24-Hour \(ASA24\) Dietary](#)

Assessment Tool: ASA24 is a freely available web-based tool from NCI for epidemiologic, interventional, behavioral, or clinical research that enables multiple automatically coded, self-administered 24-hour recalls and food records.

The ASA24 system will have an optional sleep module that was made available in late 2021. The sleep module can be used to examine the relationship between diet, sleep, and timing of eating occasions, including intermittent fasting.

Catalogue of Surveillance Systems: This website provides one-stop access to more than 100 publicly available data sets relevant to childhood obesity research, developed by the National Collaborative on Childhood Obesity Research, a public-private partnership supported in part by NIH.

¹² www.cdc.gov/nchs/fastats/leading-causes-of-death.htm.

¹³ www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2022.html.

Diet History Questionnaire (DHQ): The DHQ is a free food frequency questionnaire developed by NCI staff for use by researchers, clinicians, or educators.

Dietary Assessment Primer: This resource helps researchers determine the best way to assess diet for any study in which estimates of group intake are required.

Healthy Eating Index (HEI): The HEI is a measure of diet quality, independent of quantity, that can be used to assess compliance with the Dietary Guidelines for Americans and monitor changes in dietary patterns.

Measures Registry Resource Suite: The Measures Registry Resource Suite, developed through a public-private partnership, offers research tools spanning four domains of childhood obesity research: diet, physical activity, the food environment, and the physical activity environment. It includes the Measures Registry, Measures Registry User Guides, Measures Registry Learning Modules, and Measures for Children at High Risk for Obesity Decision Tree.

World Cancer Research Fund (WCRF)/American Institute for Cancer Research (AICR) Score: The 2018 WCRF/AICR Score is a standardized scoring system that can be used by researchers to assess adherence to the 2018 WCRF/AICR Cancer Prevention

Recommendations and examine associations with cancer-related and other health outcomes.

Health Behaviors Research Branch: The branch aims to support research at multiple levels of analysis to improve cancer-related health behaviors and risk factors.

The Classification of Laws Associated with School Students (CLASS): CLASS protects the well-being of students by monitoring, classifying, and evaluating physical education and nutrition policies across the United States.

Metabolic Epidemiology Branch: The branch's research mission is to conduct collaborative high-impact epidemiological research on metabolic and lifestyle causes of cancer that will guide prevention and early intervention strategies worldwide.

Nutritional Science Research Group (NSRG): The NSRG promotes and supports studies establishing a comprehensive understanding of the precise role of diet and food components in modifying cancer risk and tumor cell behavior.

Trans-NCI Obesity and Cancer Working Group: The purpose of the work group is to promote the exchange of information and crosscutting interests in obesity and cancer research within NCI.

RESEARCH DIRECTIONS

NCI supports extensive research on the relationship between nutrition and cancer in a wide variety of areas spanning the prevention, therapy, and survivorship domains, including studies that focus on basic molecular and cellular mechanisms of action of bioactive food components, dietary assessment

methods, etiology, risk factor monitoring, and development of evidence-based interventions. Among the many research approaches being pursued or encouraged, the following are of particular importance:

Dietary Assessment Methods

- ▶ Innovative and novel technologies for assessing diet, physical activity, sleep, and weight control behaviors, such as the ASA24 Dietary Assessment Tool, electronic handheld monitoring devices, and digital technologies that are approached in collaboration with other NIH institutes
- ▶ Identification and validation of biomarkers of dietary intake to assess the accuracy of dietary assessment methods commonly used in epidemiology, intervention, and surveillance research
- ▶ Improved diet, physical activity, and sleep assessment methodology across culturally diverse populations
- ▶ Studies to examine patterns of multidimensionality and dynamism of diet, including diurnal patterns and patterns over the life course

Molecular Targets for Bioactive Food Components

- ▶ Preclinical and clinical studies using genomic, epigenomic, proteomic, and metabolomic approaches to identify critical bioactive food components and their sites of action in the cancer process
- ▶ Clinical studies to characterize inter-individual variability in biological responses to diet and how responses influence cancer risk and prevention
- ▶ New approaches to integrate -omic information to understand consumption of specific nutrients and foods and/or dietary patterns and biological responses related to cancer pathways
- ▶ Preclinical and clinical studies to understand the interplay between nutrition, the microbiome, immune function, and cancer prevention

- ▶ Clinical studies to examine biological effects of microbial-generated metabolites from food components and their role in cancer prevention, etiology, and cancer health disparities
- ▶ Clinical and mechanistic studies on the effects of prebiotics and probiotics found in food or food components; their interaction with members of the gut, mouth, and skin microbiota; and their role in carcinogenesis and metabolism
- ▶ Essential and nonessential food components as modifiers of carcinogen metabolism, DNA repair, cell proliferation, differentiation, immunocompetence, hormonal homeostasis, and apoptosis
- ▶ Novel technologies for evaluating metabolic profiles, genetic susceptibilities, and predispositions to cancer as influenced by diet
- ▶ Transdisciplinary research to discover and characterize mechanisms by which diet, weight, physical activity, and sleep interact with genetic and other factors in cancer development and progression
- ▶ Food preparation and processing methods—as well as variation in food, alcohol, fat, and fiber intake—as modifiers of biomarkers or tumor incidence
- ▶ Interdependence of obesity, physical activity and sedentary behaviors, sleep, and inflammatory responses in establishing cancer risk and tumor behavior through various epidemiologic, clinical, and preclinical investigations
- ▶ Physiological responses to defined dietary patterns to determine their role in cancer incidence and tumor behavior
- ▶ Studies that examine psychosocial, generational, and environmental correlates of cancer-related behaviors, including diet, physical activity, sleep, and tobacco use
- ▶ Investigating the mechanisms for which diet and nutritional interventions and physical activity affect the response to cancer treatment or cancer recurrence
- ▶ Nutritional requirements of the cancer patient and neoplastic tissues, with emphasis on nutrient uptake, utilization, and cellular control mechanisms in both normal and neoplastic tissues and on host–tumor interactions and competition for nutrients

Population Surveillance, Economics, and Policy

- ▶ Population-level monitoring of diet and other risk factors for the refinement of nationwide surveys, such as the National Health Interview Survey and National Health and Nutrition Examination Survey
- ▶ Cohort Consortium to collect enhanced self-report and objective measures on diet and bioactive food components
- ▶ Collaboration with the National Center for Health Statistics (NCHS) on nationwide surveys to enhance self-report, biologic, and genetic measures for monitoring and examining the impact of behaviors related to energy balance and cancer
- ▶ Public comprehension of health recommendations on diet and physical activity through the NCI Health Information National Trends Survey (HINTS)
- ▶ NIH-wide initiative to support innovative economic research on diet, physical activity, and energy balance to examine societal, market, and economic forces that may influence nutrition and related practice, particularly in at-risk populations
- ▶ Private–public initiatives to develop research resources to track legislation and policies related to diet, physical activity, and weight control to assist in the understanding of factors influencing decisions at the population level and within clinical practice

Development of Evidence-Based Interventions

- ▶ Transdisciplinary research to develop effective, innovative approaches with broad population impact at the social, environmental, and policy levels for prevention of obesity-related cancers
- ▶ Clinical dietary intervention trials related to specific diets, nutrients, foods, and food components and their effects on cancer incidence and tumor behavior
- ▶ Genomic technologies to identify those who respond maximally to dietary intervention and those who might be at risk of poor cancer health outcomes due to diet and nutritional alterations
- ▶ Cost-effective approaches using food components for prevention and therapeutic strategies within clinical interventions

- ▶ Clinical trials to evaluate the effectiveness of nutritional support in the rehabilitation of the cancer patient, nutrition requirements during the spectrum of cancer care, and nutrient and dietary factors needed to maximize patient survival
- ▶ Clinical trials to assess the effects of diet and weight loss on cancer recurrence
- ▶ Research to understand the effects of intermittent fasting patterns on health and disease
- ▶ Behavioral research to identify evidence-based behavioral approaches for improving diet, physical activity, and weight management practices
- ▶ Systems research to assess the effects of the built environment on food access and dietary behaviors on cancer risk
- ▶ Research methodologies for improved empirical study of cancer-relevant behaviors (e.g., diet, physical activity, energy balance, and environmental exposures) and the relationships to the psychosocial and built environments (e.g., measures of psychosocial correlates of eating patterns and physical activity and of the obesogenic environment, along with food consumption and dietary related biomarkers and the interaction between the environment and psychosocial factors associated with cancer-preventive health behaviors)

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NATIONAL CENTER FOR COMPLEMENTARY AND INTEGRATIVE HEALTH

<https://nccih.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$21,449,270
Nutrition as Percentage of Total IC Obligations for FY21	12.4%

OVERVIEW

The National Center for Complementary and Integrative Health (NCCIH) is the federal government's lead agency for scientific research on complementary and integrative health. The center's mission is to determine, through rigorous scientific investigation, the fundamental science, usefulness, and safety of complementary and integrative health approaches and their roles in improving health and health care. NCCIH supports research on a diverse group of nondrug and noninvasive health practices encompassing nutritional, psychological, and physical approaches that may have originated outside of conventional medicine, many of which are gradually being integrated into mainstream health care. These include natural products—such as dietary supplements, plant-based products, and probiotics—as well as mind and body approaches—such as yoga, massage therapy, meditation, mindfulness-based stress reduction, spinal and joint manipulation, and acupuncture. In clinical practice, these approaches are often combined into multicomponent therapeutic systems—such as traditional Chinese medicine, Ayurveda, chiropractic, osteopathy, and naturopathy—that have distinctive underlying diagnostic and theoretical frameworks. Integrative health care seeks to bring conventional and complementary approaches together in a safe, coordinated manner, with the goal of improving clinical care for patients, restoring health, promoting resilience, and preventing disease.

NATURAL PRODUCTS RESEARCH

Establishing priorities across the field of complementary and integrative health research is enormously challenging. NCCIH-supported research clearly intersects with nutrition, as is exemplified by the NCCIH's robust natural products research portfolio, which includes research on dietary supplements, herbal and botanical products, probiotics, and food-based phytochemicals. NCCIH also supports research on certain

types of diets (e.g., ketogenic). The center's research on natural products relies heavily on the methods and tools of pharmacology and pharmacognosy. NCCIH has established rigorous standards and policies for the quality and integrity of products used in NCCIH-supported research. Further information on the [NCCIH policy on the integrity of natural products](#) is available on the center's website.

RESEARCH DIRECTIONS

NCCIH research priorities are guided by its [Strategic Plan](#). Our primary research objectives are as follows:

- ▶ Advance fundamental science and methods development.
- ▶ Advance research on the whole person and on the integration of complementary and conventional care.
- ▶ Foster research on health promotion and restoration, resilience, disease prevention, and symptom management.
- ▶ Enhance the complementary and integrative health research workforce.
- ▶ Provide objective, evidence-based information on complementary and integrative health interventions.

NCCIH has a broad interest in studying the biological activities of such natural products as prebiotics, probiotics, dietary supplements, botanicals, and vitamins. A strong research emphasis is placed on products for which there is compelling preclinical evidence of potential biological activity that may lead to a health benefit or treatment intervention and products that are widely used by the American public. Many of the natural products used by individuals are complex, with multiple molecular constituents that may contribute to their effects. To fully understand the activity of complex mixtures, it is necessary to identify the individual components responsible for a specific activity and determine how those components interact with other components and biological targets. Preclinical model systems are valuable for these studies. Clinical trials of natural products are maximally informative if they incorporate well-formulated biological hypotheses,

are built on a sound foundation of basic mechanistic and pharmacologic understanding, and incorporate an assessment of defined signatures of biological effects. Thus, the design of maximally informative clinical efficacy trials of natural products requires mechanistic insight as a first step.

NCCIH will continue to support research on isolated natural product compounds and the complex mixtures from which they originate. Studies also may focus on both the potential beneficial and harmful effects of natural products, including their interactions with medications. NCCIH-supported studies also may include the characterization of novel natural products or the discovery of the biological activity of chemical constituents in a complex mixture.

Historically, NCCIH has supported most basic and translational research and development activities relevant to complementary approaches in natural products research through investigator-initiated research grants. This is augmented with targeted initiatives to address high-priority research topics. [Solicitations across the broad spectrum of NCCIH's research](#) may be found on the center's website.

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This broad-based approach has yielded a robust pipeline of basic to clinical research, as well as a large body of information and promising leads for future research. For example, NCCIH is supporting a Center of Excellence for Natural Product Drug Interaction Research that is focused, in part, on conducting rigorous human subject studies to establish the clinical relevance of interactions for selected natural products. NCCIH also supports rigorous screening of natural product libraries in assays with clear relevance to human metabolism for evidence of pharmacokinetic interactions. The data generated will provide additional information on potential interactions and help inform prioritization strategies regarding which natural products may warrant future investments in clinical studies.

NCCIH also will continue to support research to elucidate the effects of probiotics and prebiotics on the microbiota naturally present in the human body. It seeks to address fundamental knowledge gaps, including those pertaining to molecular mechanisms of action of the microbiota and potential interactions with pre- and probiotics and their impact on processes in the human body. NCCIH will continue to work closely with other NIH institutes, centers, and offices—including the NIH ONR and ODS, FDA, and USDA—to leverage its investments in this research area.

NATIONAL EYE INSTITUTE

https://www.nei.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$18,672,702
Nutrition as Percentage of Total IC Obligations for FY21	2.3%

OVERVIEW

The mission of the National Eye Institute (NEI) is to eliminate vision loss and improve quality of life globally through vision research. The global burden of vision impairment is estimated to be 1.1 billion individuals—43 million of whom are blind.¹⁴ However, more than 90 percent of visual impairment cases are considered treatable or preventable. Nutrition is a key component of eye health. For example, vitamin A deficiency can cause xerophthalmia, a form of blindness found in children and pregnant women in some lower- and middle-income countries. Although there is truth to the popular notion that eating carrots is good for your eyes (carrots are rich in beta-carotene, a building block of vitamin A production), NEI research broadly evaluates the effects of nutritional factors, such as vitamins and trace minerals with antioxidant capabilities, in preventing eye disease. The Age-Related Eye Disease Study (AREDS), a major NEI epidemiological and randomized placebo-controlled trial showed that high levels of antioxidants (vitamins C and E and beta carotene) and zinc plus copper reduced the risk of progression to late age-related macular degeneration (AMD) by 25 percent in 5 years for those at high risk. Beta-carotene can increase the risk of lung cancer in current and former smokers. The AREDS2 trial demonstrated that a new formulation substituting the antioxidants lutein and zeaxanthin for beta-carotene provides a safe and effective treatment for people at risk of late AMD and that the addition of omega-3 fatty acids to the AREDS supplements had neither a beneficial nor a harmful effect on progression to late AMD.

RESEARCH DIRECTIONS

The following projects represent some of the nutrition-related research areas supported by NEI:

- ▶ NEI convened a nutrition workshop that focused on B vitamins and very-long-chain fatty acids. Analyzing AREDS and AREDS2 data, NEI investigators discovered that tracking the severity of AMD progression over 2 years can predict the likelihood of vision loss 5 years later, suggesting that this scale can be used to shorten clinical trials focused on AMD and bring treatments earlier to people who need them.
- ▶ Carotenoid levels are known to vary by individual and are influenced by such factors as dietary sources, total nutrient intake, vitamin supplementation, genetics, and metabolism. After 15 years of follow-up with a cohort of women who participated in the Women's Health Initiative, NEI-supported researchers observed that higher carotenoid levels were associated with larger retinal vessels, indicating a clinically significant relationship between carotenoid levels and incidence or progression of age-related eye disease, specifically macular degeneration.
- ▶ Macular pigment (MP) is composed of the dietary carotenoids lutein, zeaxanthin, and meso-zeaxanthin and declines with age. NEI scientists are investigating MP as a modifiable risk factor for AMD and how preserving MP might help reduce risk of developing eye diseases and vision loss. On the developmental end of the spectrum, evidence indicates that pregnant women actively transport carotenoids via the placenta, yet lutein and zeaxanthin are rarely incorporated into prenatal vitamins. A randomized clinical trial is testing the hypothesis that lutein and zeaxanthin supplementation will have benefits for both mother and baby, testing such outcomes as maternal visual acuity and infant foveal structure at birth.
- ▶ Dry eye disease (DED) affects approximately 14 percent of the U.S. population, and it is common practice for DED patients to take supplements as part of their treatment. The Dry Eye Assessment and Management (DREAM) study is an NEI-funded, randomized trial that investigated the effects of omega-3 fatty acid (fish oil) supplementation on DED patients across 27 U.S. sites. DREAM investigators found that fish oil supplements are no better than placebo. Ongoing secondary data analyses of DREAM data have identified important systemic risk factors for DED.
- ▶ Cocoa products contain epicatechins, a subclass of flavonoids that have potential benefits on vasodilation and blood pressure. NEI has funded the COcoa-Supplement

¹⁴ Burton MJ, et al. The Lancet Global Health Commission on Global Eye Health: vision beyond 2020. *Lancet Glob Health*. 2021 Apr;9(4):e489-e551. doi: 10.1016/S2214-109X(20)30488-5. Epub 2021 Feb 16. PMID: 33607016; PMCID: PMC7966694.

and Multivitamins Outcomes Study (COSMOS) eye trial to examine the efficacy of cocoa extract supplements in reducing the risk of AMD and cataract development in a cohort of patients who are participating in the COSMOS trial.

- ▶ NEI has funded research investigating vitamin D metabolism in the cornea and in tear fluid. Although vitamin D is predominantly produced in the skin in response to UV sunlight, the cornea also may produce it. Vitamin D may have many roles in the eye, from healing wounds to controlling intraocular pressure. In a prespecified ancillary study to the VITamin D and OmegaA-3 Trial (VITAL), NEI investigators found that after 5 years of follow-up, neither daily supplementation with vitamin D nor with omega-3 fatty acids had a significant overall effect on AMD incidence or progression.
- ▶ Vitamin A is the precursor for 11-cis-retinal, a molecule essential for vision. Investigations into vitamin A, its derivatives, and the proteins that bind and transport it to cells are a major focus of NEI-supported research. Scientists are exploring the role these substances play in the normal metabolism of ocular tissues and in the visual cycle. Increasing evidence shows the importance of vitamin A derivatives and their binding proteins as potential therapeutic targets. Researchers have found that chronic deficiency of vitamin A has an effect on ocular tissue integrity and metabolism.
- ▶ Animal models for AMD are often limited because only primate eyes have maculae, the small photoreceptor-rich region of the central retina needed for fine, detailed vision. NEI grants support researchers in studying three aging primate (macaque) populations that have had controlled diets from previous research: (1) monkeys with lifelong healthy diets; (2) monkeys with otherwise healthy diets but devoid of the carotenoids lutein and zeaxanthin; and (3) aging monkeys with diets high in fat and sugar, mimicking a typical American diet. Animal models also are being used to investigate carotenoid-related gene profiles during infancy, comparing infants fed with breastmilk, formula, and carotenoid-supplemented formula.
- ▶ Premature, low birth weight infants are at high risk for retinopathy of prematurity (ROP), a leading cause of ocular blindness in children. An NEI study suggested that adding dietary fatty acids increases levels of adiponectin, which communicates with the retina to regulate the creation of disease-causing blood vessels (neovascularization) in the eye. Additionally, a recent clinical trial in Sweden demonstrated that supplementing the diet of most premature infants with a lipid solution reduced the prevalence of ROP by 50 percent.

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NATIONAL HEART, LUNG, AND BLOOD INSTITUTE

https://www.nhlbi.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$251,887,494
Nutrition as Percentage of Total IC Obligations for FY21	5.4%

OVERVIEW

Heart diseases remain the leading causes of death in the United States, although the past decade has seen a remarkable decline in the disease prevalence in the overall population.¹⁵ The prevalence of heart disease and stroke appears to be increasing among minority groups,¹⁶ and the rate of decline in heart disease prevalence has slowed. Chronic lower respiratory diseases rank sixth among the 10 leading causes of death, which account for 74 percent of all deaths in the United States.¹⁷ Racial/ethnic minority groups are more adversely affected than other groups. These diseases, which are within the purview of the National Heart, Lung, and Blood Institute (NHLBI), impose a heavy burden on the health and economy of the American people. Taken together, cardiovascular, lower respiratory, and cerebrovascular diseases accounted for three of the six leading causes of death in U.S. adults.¹⁷ These diseases also account for 29.8% of all deaths in 2020.³ In the United States, the number of deaths attributable to cardiovascular disease (CVD) declined from 1999 until 2011, but increased each year from 2012 to 2020 for a total increase of nearly 18% (from 787,431 deaths in 2012 to 928,741 deaths in 2020).^{16,18} The estimated direct and indirect economic cost of heart, lung, and blood diseases in the United States was \$522.2 billion between 2018 and 2019.^{4,5} The total economic loss due to sleep deficiency and related disorders in the United States is estimated to be \$411 billion.¹⁹

Nutrition is a major contributor to population health in the United States and globally, and recent estimates suggest that diet-related risk factors contributed globally to 11 million deaths and 255 million disability-adjusted life years.²⁰ An important overall goal of the NHLBI nutrition research program is to promote cardiovascular health and prevent and treat CVDs—such as heart attack, stroke, arrhythmias, peripheral arterial disease, and heart failure—and their risk factors. With heart disease as the nation's number-one killer, an important focus of the research is to reduce risk by examining the influence of nutrition and physical activity on such well-characterized risk factors as high blood cholesterol levels, high blood pressure, obesity, and poor levels of cardiovascular and physical fitness. Consequently, clinical trials also are needed to develop effective solutions to promote cardiovascular and respiratory health. Emerging cardiovascular risk factors—including the gut microbiome, inflammatory response markers, and metabolites, such as Trimethylamine N-oxide (TMAO)—also may be influenced by nutrition, and it is hoped that a better understanding of these relationships will ultimately provide new approaches to prevent and treat heart diseases. Some cases of congenital heart disease also appear to have a nutritional basis and thus may be prevented by improving maternal diets and/or nutritional status. Gene–diet interactions and epigenetic changes, as evident from research on developmental origins of diseases, have been reported, including adverse prenatal and early-life exposures and the lifelong consequences on metabolic risk and health outcomes.

Other critical goals of the NHLBI nutrition research program include prevention and treatment of lung diseases, such as asthma and chronic obstructive pulmonary disease, and blood diseases, such as clotting disorders and sickle cell disease. Recent advances

¹⁵ Mensah GA, Wei GS, Sorlie PD, et al. Decline in cardiovascular mortality: possible causes and implications. *Circulation Research*. 2017;120(2):366-380.

¹⁶ Virani SS, Alonso A, Aparicio HJ, et al. Heart disease and stroke statistics—2021 update: a report from the American Heart Association. *Circulation*. 2021;143(8):e254-e743.

¹⁷ Murphy SL, Kochanek KD, Xu J, Arias E. Mortality in the United States, 2020. Centers for Disease Control and Prevention, National Center for Health Statistics. National Vital Statistics System: public use data file documentation: mortality multiple cause-of-death micro-data files. Accessed February 17, 2022. https://www.cdc.gov/nchs/nvss/mortality_public_use_data.htm.

¹⁸ Agency for Healthcare Research and Quality. Medical Expenditure Panel Survey (MEPS): household component summary tables: medical conditions, United States. Accessed February 17, 2022. https://www.meps.ahrq.gov/mepsweb/about_meps/survey_back.jsp.

¹⁹ Hafner M, Stepanek M, Taylor J, Troxel WM, Van Stolk C. Why sleep matters—the economic costs of insufficient sleep: a cross-country comparative analysis. *Rand Health Quarterly*. 2017;6(4).

²⁰ Afshin A, Sur PJ, Fay KA, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*. 2019;393(10184):1958-1972.

demonstrate that sleep and the circadian clock mediate behavioral, physiological, and molecular processes fundamental to energy metabolism and cardiometabolic pathophysiology. Sleep deficiency triggers neural, autonomic, and endocrine mechanisms, resulting in changes in appetite regulation, calorie intake, adipose function, and energy expenditure.^{21,22} The molecular circadian clock serves as a cellular energy sensor that responds to dietary nutrients, re-dox state, and adenosine triphosphate availability, in turn driving 10 to 20 percent of gene expression in metabolically active tissues.^{21,22} The circadian clock is well positioned to integrate nutrient signaling, cellular metabolism, and systemic physiology contributing to obesity and obesity-related CVD.

The scope of the NHLBI nutrition research program encompasses the full research spectrum, including basic investigations, epidemiologic and observational studies, clinical and community intervention studies, and translation and implementation science research. NHLBI also fosters collaboration to apply research results and leverage resources

to address public health needs nationally and internationally. In addition, NHLBI supports academic and professional training in nutrition research and clinical nutrition, as well as the development of innovative nutrition education programs for medical students, residents, attending physicians, and other health care professionals.

RESEARCH DIRECTIONS

Some of the main points of emphasis in the NHLBI nutrition research program include the following:

Heart and Vascular Diseases

Mechanisms and Risk Factors

- ▶ Identify dietary patterns, foods, nutrients, and other dietary components that are effective in improving blood pressure, lipids, glucose, and overall cardiovascular health, and determine the mechanisms by which these effects are achieved.
- ▶ Evaluate the relationship between physiologic- and pharmacologic-level intake of nutrients and other dietary components with the pathophysiology of atherosclerosis and other CVD mechanisms.
- ▶ Investigate the interaction of nutrients or dietary factors with pharmacologic agents to reduce CVD risk.
- ▶ Investigate the interaction of nutrients or dietary factors with the gut microbiome as a mediator of cardiovascular risk-associated inflammation.
- ▶ Investigate role of diet-microbiota interrelationships in the development of CVD prevention or progression through lipid metabolism or other pathological processes.
- ▶ Conduct studies using animal models to study how hypertension, dyslipidemias, obesity, and other nutrition-related cardiovascular risk factors affect and damage organs in the body.
- ▶ Investigate the interactions between genetic factors and diet as they influence CVD risk.
- ▶ Conduct studies using new biomarkers of nutrient metabolism to understand the causation, prevention, or treatment of CVDs.
- ▶ Investigate how racial, ethnic, and gender differences in dietary patterns influence nutrition-related CVD risk, nutrient metabolism, dietary habits, and responsiveness to dietary intervention.
- ▶ Explore gene-diet-health interrelationships, including ancestry-based differences.
- ▶ Understand metabolic flexibility and utilization of and shifts in fuel substrate in the heart failure subtypes with a focus on comorbidities, such as diabetes and glucose-related metabolic disorders.
- ▶ Elucidate the role of body weight and fat distribution as related to the development of CVD and its risk factors.
- ▶ Determine the relative roles of physical activity and diet in achieving energy balance, healthy body weight, fat loss, changes in body fat distribution, and long-term maintenance of weight loss.
- ▶ Investigate mechanisms and implications of unintended weight loss in low- to moderate-risk populations and on heart failure prevention and treatment.
- ▶ Understand metabolic and CVD phenotypes of poorly characterized genes and pathways involved in circadian clocks, metabolism, or metabolic and nutrient signaling.
- ▶ Examine the influence of ultra-processed food and food quality on cardiovascular risk and cardiometabolic pathways.

²¹ Maury E. Off the clock: from circadian disruption to metabolic disease. *International Journal of Molecular Sciences*. 2019;20(7):1597.

²² Krishnaiah SY, Wu G, Altman BJ, et al. Clock regulation of metabolites reveals coupling between transcription and metabolism. *Cell Metabolism*. 2017;25(4):961-974. e4.

Intervention and Translation Research

- ▶ Investigate the effects of macro- and micro-nutrients, functional foods, dietary supplements, and complementary and alternative therapies in the prevention and treatment of CVD.
- ▶ Determine the optimal amount, type, and intensity of physical activity or fitness level needed for weight control, optimal nutrient intake, and cardiovascular health and the contribution of sedentary behaviors to cardiovascular risk.
- ▶ Identify influences of the built, home, psychosocial, and sociocultural environments on dietary behavior, and develop and test interventions targeting these influences.
- ▶ Develop and test intervention strategies that focus on the interactions among individual dietary behaviors and choices (e.g., habits, portion, meal timing and frequency, preparation, purchasing), genetics, and the environment (e.g., home, community, built environment) to reduce cardiovascular risks, particularly those targeting different literacy levels, socioeconomic levels, and race/ethnic groups.
- ▶ Characterize behavioral determinants of adherence to dietary and physical activity recommendations and develop effective interventions to improve adherence.
- ▶ Develop effective strategies and materials for the dissemination of nutrition and disease prevention information aimed at health professionals and the public of different ages, literacy levels, and ethnic backgrounds.
- ▶ Develop and test lifestyle interventions to prevent obesity and excessive weight gain across the lifespan and for long-term maintenance of weight loss, particularly interventions that are practical, cost-effective, sustainable, and have high potential for broad-scale dissemination.
- ▶ Conduct clinical trials that are informed by system science approaches and computational biology.
- ▶ Conduct clinical trials comparing the CVD impacts of different diets (e.g., plant protein versus animal protein diets, vegetarian diets, ultra-processed diet).
- ▶ Develop dietary intervention trials that address chronic disease across the lifespan.
- ▶ Design trials exploring the role of micronutrient intakes and deficiencies in CVD prevention, treatment, and management.
- ▶ Conduct clinical trials to understand how nutrition, medication, or devices affect fuel utility or fuel shifts in heart failure patients.
- ▶ Design trials to study the effects of diet among the large percent of the population taking statins and lipid-lowering drugs.
- ▶ Conduct interventions to determine how the effects of diets—such as Na/K ratios, level of food “processing,” eating rate, and caloric density—affect CVD risk factors.

Assessment/Epidemiologic

- ▶ Advance the state of the art in dietary intake methodology, including dietary assessment tools, statistical techniques, and food composition analysis, methods, standard reference materials, databases, and software.
- ▶ Develop improved technologies for assessing energy balance, intake, and expenditure under research conditions and in real-world settings.
- ▶ Identify behavioral, social, and environmental determinants of nutrient intake, dietary patterns, and health that relate to or affect cardiovascular risk.
- ▶ Identify novel chronic disease biomarkers and biomarkers of nutritional status.

Lung Diseases

- ▶ Investigate the role of maternal nutrition in fetal lung development.
- ▶ Investigate the role of nutrition in the development of normal pulmonary immune defense systems, especially during lung development.
- ▶ Explore the role of nutrition in preventing respiratory muscle dysfunction in acute and chronic pulmonary disease.
- ▶ Study the impact of the nutritional substrate on metabolic rate and respiratory function.
- ▶ Study the role of malnutrition in the mother and baby in the development of bronchopulmonary dysplasia.
- ▶ Study the role of nutrition in chronic respiratory failure, such as bronchopulmonary dysplasia, muscular dystrophy, and ventilator dependence.
- ▶ Study the role of vitamins in lung development.

- ▶ Study the impact of nutrition on the infant gut and pulmonary microbiome.
- ▶ Investigate the role of nutrition in the development of normal pulmonary immune defense systems, especially during lung development.
- ▶ Explore the role of nutrition in preventing respiratory muscle dysfunction in acute and chronic pulmonary disease.
- ▶ Examine the mechanisms of beneficial effects of dietary fiber on pulmonary health.
- ▶ Investigate maternal nutritional supplementation and impact on lung development and long-term pulmonary health.
- ▶ Explore the anti-inflammatory effects of omega-3 fatty acids and their effects on the progression of pulmonary disease and asthma.

Sleep Diseases and Disorders

- ▶ Investigate the relationship between sleep apnea (sleep-disordered breathing) and obesity, as well as the effect of dietary factors on the control of breathing and airway function.
- ▶ Determine the health-related consequences of sleep deficiency (i.e., insufficient sleep duration, circadian misalignment, poor sleep quality) on increased disease risk for nutrition-related conditions, such as obesity, cardiopulmonary diseases, and diabetes.
- ▶ Develop biomarkers of insufficient sleep and circadian rhythm disruption to optimize diagnostic and intervention timing and improve cardiometabolic outcomes.
- ▶ Develop and evaluate accurate and objective measures and assessments for chronotype and dietary/nutrition status including simple screening tools that could be used easily in clinical and public settings.
- ▶ Elucidate circadian-dependent mechanisms coupled to behavioral, physiological, and cellular mediators of nutrient metabolism and related cardiometabolic pathophysiology.
- ▶ Identify biomarkers and molecular signatures of sleep deficiency that predict increased risk or point to novel therapeutic targets for nutrient-related cardiopulmonary and metabolic disease.
- ▶ Delineate the consequences of maternal sleep disorders on nutrient metabolism and nutrient-related conditions (e.g., obesity, diabetes, hypertension) in offspring across childhood and adolescence.
- ▶ Investigate the role of specific nutrients in adult and infant respiratory distress syndromes.

Blood Diseases

- ▶ Investigate the role of food insecurity and food deserts in obesity and overweight in hemoglobinopathy patients.
- ▶ Identify the mechanism(s) by which nutrients and other dietary factors influence the synthesis and expression of functional activity of platelets and of proteins involved in the coagulation of blood.
- ▶ Elucidate the role of nutrients and other dietary factors in the genesis, treatment, and prevention of blood vessel obstruction.
- ▶ Investigate energy balance and nutrient requirements among children with sickle cell disease, especially children who fail to thrive, and adolescents who are in a rapid growth phase.
- ▶ Conduct studies on the benefits of appropriate dietary intervention and nutritional supplementation in hemoglobin disorders.
- ▶ Improve understanding of nutritional factors in the management and clinical variability of hemoglobin disorders. Characterize the relationship between nutritional deficiencies and immune dysfunction in sickle cell disease.
- ▶ Elucidate mechanisms of nutrient and red blood cell interactions (e.g., omega-3 and red blood cell rigidity), as well as the pathophysiology of thrombotic conditions.
- ▶ Evaluate the safety and efficacy of iron supplementation and methods of administration for special populations (e.g., individuals with risk for bone loss).
- ▶ Explore mechanisms and dietary causes of, and develop nutrition interventions for, red blood cell fragility and hemolytic anemias (e.g., favism, other forms of anemia and thrombolytic conditions).
- ▶ Identify mechanisms for specific nutrients and physiology of thrombosis, as well as pathophysiology of thrombotic conditions.

Crosscutting Research Areas

Minority Health and Health Disparities

- ▶ Characterize health disparities and underlying causes of these disparities in heart, lung, blood, and sleep (HLBS) diseases and conditions.
- ▶ Explore social determinants of health and their contributions to health disparities observed in HLBS diseases and conditions.
- ▶ Develop innovative and culturally relevant clinical trials to address minority health and health disparities of HLBS diseases.

Women's Health

- ▶ Explore research in maternal health and maternal morbidity and mortality and how diet and nutrition affect these outcomes.
- ▶ Implement and evaluate interventions that address infant and child cardiometabolic risks and maternal morbidity and mortality.
- ▶ Study the nutritional requirements of the aging population, particularly among older adult women.

Training

- ▶ Train the next generation of researchers in HLBS diseases and disorders.
- ▶ Apply emerging nutrition research in clinical and medical practice and training.

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NATIONAL HUMAN GENOME RESEARCH INSTITUTE

https://www.genome.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$10,408,983
Nutrition as Percentage of Total IC Obligations for FY21	1.6%

OVERVIEW

Since the completion of the Human Genome Project in 2003, National Human Genome Research Institute (NHGRI)-supported research has focused on advancing genomic science and medicine through a deeper understanding of genome structure and function; the relationships between genes, environment, and human health; and attitudes and behaviors related to genomic information.

As part of its mission to advance genomic science and medicine, NHGRI funds research on the complex relationships between genomics and nutrition-relevant variables. Genomics plays an essential role in individual variation in metabolism and predisposition for genetically complex diseases, including obesity, diabetes, heart disease, and cancer. NHGRI supports studies to investigate the interplay between genetic and environmental risk factors for these complex diseases in multiethnic cohorts. In addition, NHGRI funds research on how people understand and use genomic information related to obesity risk to shape food and nutrition choices.

RESEARCH DIRECTIONS

NHGRI supports research on genomic and environmental interactions (GxE), including the interactions of genes and diet and nutrition.

NHGRI-funded investigators are elucidating complex interactions between genetics and environmental exposures to inform our understanding of the contributions of metabolism, diet, and eating behaviors to human health and disease.

Two research groups, including one of NHGRI's Centers of Excellence in Genomic Science (CEGS), are using mouse models to study diet and its relationship to metabolic disease and developing novel statistical methods to measure gene-environment interactions contributing to metabolic disease states. In addition, NHGRI-funded researchers are applying novel statistical methods measuring synergistic GxE effects over time to explore the mechanism of gene-by-hormone interaction on women's eating behavior in a longitudinal study on eating disorders.

Folate and vitamin B12 are essential nutrients for cell growth and neurological development, and deficiencies increase the risk of tumors, miscarriage, birth defects including spina bifida, and age-related cognitive problems. NHGRI intramural investigators are studying genes that affect folate and vitamin B12 metabolism and contribute to disease. Detailed knowledge of the function of the genes in the folate/vitamin B12 metabolic pathways will add to the understanding of neural

tube defects and potentially help guide public health policy in the area of nutritional supplementation. NHGRI intramural investigators also are conducting clinical and epidemiological research on patients with rare inborn errors of metabolism related to vitamin B12 metabolic pathways. They have created animal models to study these conditions and are continuing to develop novel therapies to treat these disorders.

Obesity is a heritable health condition underpinned by a combination of genetic and environmental influences. Increased understanding and awareness of the heritability of obesity can help parents of children with a high risk for obesity make informed food choices and form healthy habits early on. NHGRI researchers investigated how mothers' food choices for their children are affected by information about family history and obesity risk. The researchers also looked at how genetic risk information influences mothers' feelings of guilt, factors associated with food choices for children of different genders, and how mothers' weight trajectories influenced their own health beliefs and attitudes. The researchers have built on this work by recruiting fathers to the study and surveying healthy volunteer participants to assess both parents' and other adults' beliefs about the role of genetics in specific eating behaviors. Future directions for this work include evaluating the use of virtual reality educational materials to teach individuals about the role genes and the environment play in eating

behaviors. Results could suggest possible risks and benefits of integrating genetic risk messages into behavior change intervention approaches to promote optimal body weight in childhood. Moreover, NHGRI-funded projects are studying the relationship between genetic variation and metabolism in humans, especially in a variety of diverse populations that are underrepresented in genomics research. A more robust understanding of how genetic variation affects the risk of obesity and metabolic disorders in diverse populations can lead to better methods of disease prevention and approaches to reducing health disparities. One group of scientists is analyzing whole-genome sequences to find genetic variants that contribute to obesity and metabolic disorders in Hispanic or Latino populations, with a special focus on discovering the contributions of rare variants. Another study is using samples from a large multiethnic cohort to study genetic and environmental contributions to obesity, type 2 diabetes, and other traits to create disease risk prediction models for ancestrally diverse populations. Investigators co-funded by NHGRI are also conducting an innovative randomized controlled trial of a community-based weight-loss intervention for obese African American and Latino men ages 40 to 59.

Finally, NHGRI investigators and NHGRI-funded investigators also are exploring how genetic and environmental factors contribute to complex diseases in Africans and African

Americans. Led by NHGRI, NIH's Common Fund program Human Heredity and Health in Africa (H3Africa) has projects aimed at (1) building infrastructure and capacity to understand how genetic and environmental factors contribute to obesity and cardiometabolic disease in sub-Saharan Africa and (2) carrying out studies to identify these genetic factors. NHGRI intramural investigators are participating in the development and implementation of protocols for H3Africa projects and have helped design a custom chip array for genotyping in African populations. Working in concert with the H3Africa Consortium, NHGRI intramural investigators are performing analyses to identify genes and gene pathways important to the pathophysiology of severe acute childhood malnutrition and modifiers of sickle cell disease in African populations. Intramural researchers also are conducting studies outside of the H3Africa program to understand the genetic basis of diabetes, obesity, and heart disease in African diaspora populations, as well as other projects that seek to understand metabolic disorders and dyslipidemia in populations of African ancestry. NHGRI also co-funds the Breast Milk Microbiota Influence on Infant Immunity and Growth (BEAMING) study, which aims to understand how breast milk affects the gut bacteria of infants in Nigeria and South Africa and how this, in turn, affects their growth and ability to respond to childhood vaccination.

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NATIONAL INSTITUTE ON AGING

https://www.nia.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$192,905,133
Nutrition as Percentage of Total IC Obligations for FY21	4.9%

OVERVIEW

As stated in the latest report by the Administration on Aging (AoA), 16 percent of Americans were age 65 years or older in 2019. By 2040, this number is expected to be almost 22 percent. As the long-standing mission of the National Institute on Aging (NIA) has been to support and conduct genetic, biological, clinical, behavioral, social, and economic research on aging, NIA is committed to supporting a range of research to advance the understanding of the nutritional influences on health and function during aging and to apply this information to the development of intervention strategies (pharmacological and non-pharmacological) in promoting healthy aging and the well-being of older adults with improved lifestyle and psychosocial status.

Research on nutrition and aging is supported by all four of NIA's extramural divisions—Division of Aging Biology (DAB), Division of Behavioral and Social Research (DBSR), Division of Geriatrics and Clinical Gerontology (DGCG), and Division of Neuroscience (DN). In addition, a number of laboratories within the NIA's Intramural Research Program, most notably the [Translational Gerontology Branch](#), are conducting cutting-edge research in understanding the fundamental mechanisms of aging and developing dietary and nutrition interventions to support healthy aging.

RESEARCH DIRECTIONS

NIA's priorities, ongoing research, and future directions on nutrition and aging are informed by program evaluation of research gaps and emerging topics, as well as input and recommendations from scientific advisors and NIA workshops. Topics of interest to the NIA extramural programs in these areas of research include the following:

- ▶ Cellular and molecular mechanisms of age-related changes in nutrient sensing, metabolism, homeostasis, and differential cell function in preclinical model systems (DAB)
- ▶ Effects of calorie reduction on health span and age-related pathologies (DAB and DGCG)
- ▶ The interplay between the circadian regulation and dietary interventions and its effects on circadian rhythm in older adults (DAB)
- ▶ Effects of age on physiological processes through which nutrients, drugs, and other non-nutrient substances are absorbed, metabolized, and excreted in humans and preclinical animal models (DAB and DGCG)
- ▶ Basic and clinical studies of age-related changes in nutritional requirements and dietary needs (DAB and DGCG)
- ▶ The impact of nutrition on health disparity in older Americans and special subpopulations of older people and the identification of nutritional risks in older adults with multiple chronic conditions (DGCG)
- ▶ Effects of interventions in humans as a result of different dietary patterns that affect the amount (i.e., caloric restriction), timing (e.g., intermittent fasting, time-restricted eating), macronutrient composition (e.g., high-carbohydrate, low-fat), or source (e.g., whole-food, plant-based) on the onset and treatment outcomes of age-related conditions (DGCG)
- ▶ Nutritional factors associated with physiologic and psychological changes, such as immunocompetence, cardiovascular function, neurological function, body composition, physical function, sensory perception, control of appetite, macronutrient utilization, endocrine control, genetics, cognitive health, and emotional regulation in older adults (all Divisions)
- ▶ The role of nutritional factors, including dietary supplements, in prevention and treatment of age-related degenerative diseases including diabetes, osteoporosis, neurological disorders, immune deficits, heart disease, cancer, gastrointestinal diseases, and other comorbidities (all Divisions)
- ▶ Effect of neurological changes, such as dementia, and declines in sensory reception and perception on nutrient intake (DN)

- ▶ Neural mechanisms underlying the control of eating, drinking, and satiety that affect nutrient intake in older adults (DN)
- ▶ Effect of diet, food extracts, and dietary supplements on cognition, sensory systems, and motor function in older adults (DN)
- ▶ General epidemiological studies and analysis of nutritional status and body composition and their correlates with functional measures and contribution to health disparities (DGCG and DBSR)
- ▶ Psychosocial aspects of nutrition, including studies of diet as a major factor contributing to quality of life and how diet interacts with social, environmental and lifestyle variables, including food insecurity, food environment/availability, exercise, smoking, and consumption of alcoholic beverages in older adults (DBSR)
- ▶ Behavioral aspects of dietary change, including behavioral economics and mechanistic studies of behavior change related to diet and other health behaviors in older adults (DBSR)

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NATIONAL INSTITUTE ON ALCOHOL ABUSE AND ALCOHOLISM

<https://www.niaaa.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$24,810,596
Nutrition as Percentage of Total IC Obligations for FY21	4.59%

OVERVIEW

The National Institute on Alcohol Abuse and Alcoholism (NIAAA) supports nutrition research through programs in basic and clinical sciences and seeks to identify the complex relationships between alcohol consumption, nutritional status, and health.

RESEARCH DIRECTIONS

Examples of the nutrition research encouraged and supported by NIAAA are—

- ▶ Studies on alcohol metabolism and its effect on autonomic signals involved in alcohol and food intake
- ▶ Studies on alcohol effects on the absorption, utilization, and excretion of minerals (iron, magnesium, zinc, selenium, and calcium) to clarify the role that alcohol-induced changes in these minerals may play in inducing pathological consequences of chronic alcohol consumption, such as liver fibrosis and hypertension
- ▶ Studies on ethanol alteration of the distribution of essential fatty acids and prostanoid production and the role of eicosanoids in alcohol-induced physiological changes
- ▶ The role of alcohol-induced malnutrition in the pathogenesis of fetal alcohol syndrome (FAS), including impaired placental transport of nutrients
- ▶ Studies of alcohol–nutrient interactions related to possible health risks or benefits of moderate ethanol intake
- ▶ Studies on the contribution of alcohol in modulation of the endocannabinoid system and appetite regulating peptides, such as ghrelin and leptin
- ▶ Studies of the roles of thiamin deficiency, alcohol intake, and genetic predisposition in the etiology of cellular degeneration and Wernicke-Korsakoff syndrome
- ▶ Evaluation of the role of alcohol-associated increased iron accumulation in the development of alcoholic liver disease and pancreatitis
- ▶ Evaluation of the role of alcohol-associated depletion of folate, S-adenosylmethionine, and glutathione in the development of alcoholic liver disease, pancreatitis, cardiomyopathy, and lung injury
- ▶ Understanding the role of magnesium in alcohol-associated strokes
- ▶ Understanding the role of alcohol on fat metabolism (oxidation, synthesis, and transport of fatty acids) and its connection with the development of alcoholic liver disease and muscle wasting
- ▶ Studies on the possible role of fat and protein composition of the diet in management and prevention of fatty liver, alcoholic hepatitis, or liver fibrosis and cirrhosis
- ▶ Investigation of the effects of alcohol on vitamin A metabolism and associated tissue injury
- ▶ Examination of the role of choline, betaine, retinoids, and phosphatidylcholine in the attenuation of alcoholic liver disease
- ▶ Understanding the contribution of prenatal and postnatal nutritional factors that may modify risk for FAS disease in children with prenatal alcohol exposure
- ▶ Nutritional deficits from alcohol-induced intestinal dysbiosis
- ▶ Interactions between alcohol misuse on the gut microbiome and microbial effects in the gut–brain axis
- ▶ Evaluation of the risks of alcohol use disorders after bariatric surgery procedures, such as Roux-en-Y gastric bypass, sleeve gastrectomy, and laparoscopic adjustable gastric banding

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NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES

<https://www.niaid.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$105,298,717
Nutrition as Percentage of Total IC Obligations for FY21	1.45%

OVERVIEW

Although the National Institute of Allergy and Infectious Diseases (NIAID) was established in 1948, it traces its roots back to the Laboratory of Hygiene, a bacteriological laboratory that was founded in 1887 and was the forerunner of NIH and NIAID. NIAID supports basic and clinical research in microbiology, infectious diseases, immunology, and allergy. A major component of NIAID's basic research is concerned with fundamental life processes as exemplified in microorganisms and in animal cells *in vitro*. Techniques and basic biologic principles developed because of this fundamental research in microbiology and immunology have been applied to other areas of biology and medicine, including nutrition.

The complex interrelationships among nutrition, microbial infections, and immunology have important health implications. In the developing world, more than 1.7 billion cases of infectious diarrheal disease occur annually in children under the age of 5 years. Malnutrition both predisposes to diarrhea and occurs as a result of diarrhea. Poor nutrition compromises the immune system, and children who are malnourished are more vulnerable to life-threatening infectious diseases, as well as physical and cognitive impairments. Immunodeficiency states, such as HIV/AIDS, cause malnutrition and set the stage for coinfections and comorbidities that accelerate the cycle of malnutrition and infection. Asthma and allergic diseases affect more than 60 million Americans. Surgery and trauma lay the groundwork for infection and subsequent malnutrition. Many of these infections and conditions, or their complications, can be mitigated, at least in part, by appropriate nutrition.

NIAID studies on nutrition are an integral part of the institute's research to lessen the adverse health consequences of immunologic, allergic, and infectious diseases. Of particular significance are the consequences of wasting on the underlying HIV/AIDS disease process, including its infectious and immunological complications, and the role of nutrition in the development of safe and effective vaccines against infectious diseases. Continuing concerns are the prevalence of infections among the malnourished; the effect of infections on nutritional status; host-microbiome interactions and their relationship to nutrition in health and disease; the prevalence and control of acute respiratory infections and food-borne microbial illness; and the effect of malnutrition on resistance to infection, especially to infectious diarrhea and respiratory infections, in young children.

RESEARCH DIRECTIONS

NIAID's interest in nutrition aims at a better understanding of the complex interrelationships of nutrition, immunity, and infection to expand knowledge that can be applied to develop improved diagnostics and strategies for the prevention and treatment of inflammation and infection. The institute's research directions are correspondingly varied. They include the following:

- ▶ All aspects of nutrition and the prevention, development, consequences, and treatment of HIV/AIDS; the relationship of nutrition to the development and treatment of comorbidities (such as osteopenia) associated with HIV disease and treatment; the relationship of nutrition to the pathogenesis and treatment of pediatric HIV disease, such as growth and development, including the impact of infant feeding choices; and the impact of undernutrition on absorption and pharmacodynamics of antiretroviral agents
- ▶ The negative effect of malnutrition on resistance to tropical infections, especially infectious diarrheas and tuberculosis, and the role of breast milk as a defense against enteric infections
- ▶ The role of host-microbiome interactions and their relationship to nutrition in disease and in determining optimal outcome of vaccines, immunotherapies, and organ transplantation
- ▶ The significant morbidity and mortality of rotavirus-induced infectious diarrhea among infants in developing countries and a major effort to develop a safe, effective, and practical rotavirus vaccine for newborns

- ▶ The impact of micronutrient deficiencies on the outcome of acute respiratory infections and on viral evolution, and the role of vitamin D, vitamin B6, and other micronutrients on tuberculosis and other infectious diseases
- ▶ The role of nutritional factors in the immune response to animal parasites that cause significant human disease (e.g., schistosomiasis, giardiasis, cryptosporidiosis)
- ▶ The relationship between diet, gut microbiota, and autoimmune diseases
- ▶ The modulating effects of specific nutrients (e.g., vitamins, trace elements, fatty acids, fiber, amino acids) and other ingredients, such as probiotics/prebiotics on inflammatory pathways and immune function
- ▶ Relationships between early life diet, the gut microbiome and metabolome, and the development of food allergy and other atopic diseases in childhood (NCT04798079)
- ▶ The impact of multi-food allergy on nutritional status with focus on children from low-income families (PMID: [34871793](#))
- ▶ Early introduction of allergenic foods to prevent the development of food allergy
- ▶ Development and clinical testing of immunomodulatory interventions to prevent and treat food allergies (Jones S et al., *The Lancet* 2022;399:359-71, NCT03881696, NCT03679676)
- ▶ Research to test the effects of dietary modulation on colonization resistance to *Clostridioides difficile* and microbiome composition in oncology patients (NCT04940468)

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NATIONAL INSTITUTE OF ARTHRITIS AND MUSCULOSKELETAL AND SKIN DISEASES

<https://www.niams.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$18,057,228
Nutrition as Percentage of Total IC Obligations for FY21	2.7%

OVERVIEW

The National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS) conducts and supports basic and clinical research on many of the most debilitating diseases affecting the U.S. population. These include the many forms of arthritis and numerous diseases of the musculoskeletal system and skin, as well as research on the normal structure and function of joints, muscles, bones, and skin. NIAMS is the lead institute at NIH for research on osteoporosis and related bone diseases. Basic research involves a wide variety of scientific disciplines, including immunology, genetics, molecular biology, biochemistry, physiology, virology, and pharmacology. Clinical research addresses the fields of rheumatology, orthopedics, bone endocrinology, sports medicine, and dermatology.

RESEARCH DIRECTIONS

NIAMS supports programs of research and research training in the fields of arthritis, musculoskeletal diseases, bone biology and bone diseases, muscle biology, and skin diseases. The institute has an interest in the role of nutrition in disease etiology, primary and secondary prevention of disease, improvement of physical function, and promotion of quality of life among populations with or at risk for NIAMS core mission diseases (arthritis, musculoskeletal, and skin disorders). Examples of ongoing nutrition research supported by NIAMS include the following:

- ▶ Studies on the function of diets and nutrients in osteoarthritis; muscle growth and repair; skin repair; and such autoimmune diseases as juvenile arthritis and lupus, inflammation, and joint pain
- ▶ Development of a community weight-loss program that could be scaled to improve quality of life and mobility and reduce osteoarthritis knee pain in urban and rural communities
- ▶ The role of lipolysis in regulating bone formation and repair

- ▶ Investigation of dietary risk factors for bone loss and dietary intervention to prevent bone fractures
- ▶ The impact of dietary supplements in reversing obesity-related osteoarthritis and other systemic inflammation
- ▶ Research on how obesity-related muscle loading contributes to inflammation, cartilage loss, and changes in joint morphology
- ▶ Development of a machine-learning model to predict progression of osteoarthritis that can be used by clinicians to provide individualized treatments and reduce the need for total knee arthroplasty
- ▶ The role vitamin D supplementation plays in improved oxidative metabolism and decreased atrophy, driving repair in normal and injured muscle tissue
- ▶ The translation of unique micronutrient deficiencies seen in patients with different subtypes of systemic juvenile idiopathic arthritis into the development of a urine-based biomarker assay that can be used to personalize and improve their response to treatment

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EUNICE KENNEDY SHRIVER NATIONAL INSTITUTE OF CHILD HEALTH AND HUMAN DEVELOPMENT

<https://www.nichd.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$115,079,645
Nutrition as Percentage of Total IC Obligations for FY21	6.9%

OVERVIEW

Consistent with the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) mission, the nutrition research program is focused on the continuum of human development, from pre-conception, pregnancy, and lactation through infancy, childhood, and adolescence. The nutrition research program emphasizes the evidence base needed to support domestic and global programs in health promotion and disease prevention through expanded understanding of the role of diet and nutrition in normal development, as well as the myriad conditions and stresses that can impact health.

RESEARCH DIRECTIONS

Coordinated through the Pediatric Growth and Nutrition Branch, NICHD's extramural nutrition portfolio is multidisciplinary in nature; includes basic, translational, clinical, and applied research; and is aimed at promoting health and mitigating disease during critical periods in human development. The *NICHD Strategic Plan 2020* established the following areas of focus for the extramural nutrition research portfolio:

► Human Milk Composition and Function

Information is limited regarding the composition of the bioactive components (nutritive and non-nutritive) of human milk and the functional mechanisms by which human milk components—both acting individually and together—affect the health of the infant and lactating parent.

► Nutrition for Preterm Infants

Even though preterm birth accounts for more than 10% of live births in the United States and is a strong predictor of infant morbidity and mortality, no accepted standards exist for the nutritional care of preterm infants that cover their full developmental range, from infants born at the limits of viability to those born “near term.”

► Childhood Growth

Translational studies have shown that hormones and cytokines secreted from bone and muscle may be essential for normal linear growth and skeletal development. Furthermore, translational studies suggest that bone cells secrete hormones that may regulate metabolism and fertility. However, many gaps remain in our understanding of normal growth and development, and little existing research characterizes the endocrine functions of bone or describes its effects on the multitude of temporal changes that occur during growth and development over the various stages of childhood.

► Childhood Obesity

Childhood obesity is a serious problem in the United States, with a prevalence approaching 20% in children and adolescents ages 2 to 19 years, putting affected youth at risk for poor short- and long-term health. However, the pathophysiology of obesity in youth differs from that in adults, and there is a dearth of knowledge about how to effectively prevent and treat childhood obesity, especially in high-risk populations.

NICHD involvement in NIH-wide nutrition-related research projects

- The [Nutrition for Precision Health, powered by the All of Us Research Program](#) Clinical Centers (1UG1HD107691; 1UG1HD107688; 1UG1HD107692; 1UG1HD107697; 1UG1HD107711; 1UG1HD107696) and Research Coordinating Center (1U24HD107676)

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NATIONAL INSTITUTE ON DEAFNESS AND OTHER COMMUNICATION DISORDERS

<https://www.nidcd.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$23,983,492
Nutrition as Percentage of Total IC Obligations for FY21	5.05%

OVERVIEW

The National Institute on Deafness and Other Communication Disorders (NIDCD) conducts and supports research and research training on normal mechanisms, as well as on diseases and disorders of hearing, balance, taste, smell, voice, speech, and language.

Chemical Senses—Taste and Smell

The chemical senses—more commonly known as taste, smell, and chemesthesis (chemically provoked irritation)—enable people to use chemical signals to communicate with the environment and one another. For people, memories of taste and smell experiences are vivid and long lasting and play an important role in the enjoyment of life.

The chemical senses are important for regulating food preferences and intake. They evolved to help humans and other animals survive in environments where required nutrients were scarce and many plants contained poisonous, bitter compounds. Consequently, humans seek out sweet, fatty foods and tend to reject the bitterness that characterizes many nutritious vegetables. Although this behavior made sense as humans were evolving, an almost limitless availability of high-calorie foods today can cause the normal function of taste and smell to lead to overconsumption and obesity. More than two of every three adults are considered to be overweight or obese, and more than one of every three adults is considered to be obese. Individuals who are overweight or obese are at risk of numerous serious conditions (e.g., type 2 diabetes, heart disease, and sleep apnea).

People with smell disorders often have problems appreciating the smell of foods and claim that food is less enjoyable. They may change their eating habits, which may have a long-term impact on overall health. Loss of the sense of smell may also

cause a person to add too much sugar or salt to make food taste better. This can be a problem for people with certain medical conditions, such as diabetes or high blood pressure. In addition, cancer treatments, such as radiation and chemotherapy, may result in taste and smell loss and an associated decrease in appetite, complicating treatment.

Humans seek out their preferred flavors in foods. Flavor involves interactions between the sensors that signal taste, temperature, touch, smell, and chemesthetic sensations associated with foods and the parts of the brain that interpret, remember, or think about them. Flavor plays an important role in determining whether someone accepts a particular food and how much of it they choose to eat. Scientists studying the chemical senses are interested in learning more about the molecular and developmental bases for how flavors influence food intake and overall health.

Scientists are interested in learning more about how the body detects and responds to salt, fats, and other food characteristics that humans seek out. Data gained from these studies can help determine new strategies to control overconsumption and improve health without reducing the enjoyment of food. Ongoing research is studying the structure and function of discrete taste, smell, and chemesthetic receptors, as well as their targets within the brain.

RESEARCH DIRECTIONS

NIDCD's Priority Areas in Taste and Smell Research

With the help of experts in the field of chemical senses, NIDCD has identified the following areas of research opportunity and areas where gaps in knowledge are hampering understanding.

For more detail, please refer to the [NIDCD 2017–2021 Strategic Plan for Research](#).

Priority Area 1: Understanding Normal Function

- ▶ **Fundamental Biology of Chemosensory Function:** Continue to develop and apply new tools and approaches to delineate the organization of molecules, cells, and neural circuits underlying the function of the chemesthetic (trigeminal), gustatory, and olfactory systems, including development, cell turnover, regeneration, and plasticity.
- ▶ **Peripheral and Central Bases of Flavor:** Understand the complex interactions between peripheral and central aspects of flavor perception, including retronasal or orthonasal olfaction, oral chemesthesis (chemical irritation), taste, oral somesthesis (temperature, texture), memory, and motivational state (such as hunger).
- ▶ **Sentinel/Sensory Functions:** Describe how chemical senses help us avoid dangers, such as spoiled or contaminated foods, how they detect potentially toxic chemicals in the environment and in our bodies, and how these protective functions can be damaged and regenerated.
- ▶ Genetic Aspects of Chemosensory Sensitivity
 - » **Genomics:** Identify genes involved in the development and normal function of the taste and smell systems, including the use of single-cell profiling approaches.
 - » **Variation:** Describe the normal variation in taste and smell sensitivity. Identify the genes involved to understand what is outside the range of normal function. Describe how such variation may relate to susceptibility for human communication disorders.
- » **Experience:** Identify genes involved with storing memories of taste and smell. Determine how experience influences future diet.
- » **Epigenetics:** Describe how external factors (e.g., sensory experience, diet, stress) activate and deactivate genes.
- » **Central Control of Taste and Smell:** Characterize top-down control within the central nervous system that modulates sensory input, sensory processing, and perception, and determine how such activity may change depending on internal state, motivational, or cognitive factors.
- ▶ **Developing Tools to Measure Taste and Smell Function:** Refine, develop, and apply appropriate psychophysical and behavioral methods for assessing taste and smell functions in animal models and humans. Provide practicing physicians with standardized tools to test taste and smell during physical exams or routine office visits. Develop criteria and metrics for the range of “normal” taste and smell by analogy to hearing and vision.
- ▶ **Develop Novel Approaches to Alter Taste Function:** Alter the levels of salt, sugar, and fat intake using innovative methods, such as using artificial substitutes or changing learned flavor preferences.

Priority Area 2: Understanding Diseases and Disorders

- ▶ **Genetic Disorders:** Clarify and classify taste and smell disorders caused mainly by significant genetic alterations (e.g., ciliopathies and channelopathies). Determine the normal range of variation of function in the chemical senses as related to genetic polymorphisms.
- ▶ **Environmental Insults on Taste and Smell:** Identify the mechanisms that contribute to taste and smell loss or dysfunction resulting from radiation, chemotherapy, head trauma, and toxins.
- ▶ **COVID-19:** Identify the mechanisms underlying chemosensory loss in patients with COVID-19. Develop cheap, quick, at-home objective chemosensory tests to screen for COVID. Determine if COVID-related smell loss is predictive of disease severity, other neurological manifestations, or the likelihood of developing long-term nutrition and health issues.
- ▶ **Sinusitis/Rhinitis:** Identify the molecular and cellular bases for loss of olfaction following nasal cavity or sinus infection, the most common cause of temporary and permanent olfactory loss.
- ▶ **Understanding How the Activity of the Chemical Senses Can Lead to Excessive Consumption or Malnutrition:** Determine whether calorie intake is affected by normal variation or altered function of taste and smell activity.
- ▶ **Epidemiology:** Describe the incidence and prevalence of taste and smell loss and dysfunction. For example, as the population ages, determine how many more people report taste and smell problems that affect quality of life. Enable practical approaches for wider integration of standardized chemosensory measurements into large-scale epidemiological and clinical studies.

Priority Area 3: Improving Diagnosis, Treatment, and Prevention

▶ **Improved Diagnostic Tools and Pharmacological**

Treatments: Develop and validate tests to evaluate taste and smell function that are practical and affordable for use in the office setting. Develop drugs to treat taste and smell dysfunction, especially drugs that slow apoptosis (cell death) and promote regeneration.

▶ **Regenerative Medicine/Tissue Engineering:** Increase understanding of the properties that enable stem cells in the peripheral taste and smell pathways to proliferate and

differentiate, providing insights not only for the treatment of taste and smell loss but also for the treatment of other neurological diseases.

▶ **Enhancing the Clinical Enterprise:** Promote clinical training in the chemical senses to encourage development of animal models of relevant disorders and promote clinical and translational research, involving interdisciplinary teams of clinicians and basic scientists.

Priority Area 4: Improving Outcomes for Human Communication

▶ **Translational Research:** Translational research in the chemical senses is in its infancy, due in part to the modest amount of clinical research that has been conducted. Currently, no evidence-based preventive measures, interventions, or treatments are applied to taste and smell dysfunction. Comparative effectiveness research

is premature because of the lack of intervention and treatment strategies and decisions. Because taste and smell loss become increasingly common in a population with a growing proportion of older adults, NIDCD has identified translational research in the chemical senses as a critical gap area.

OUTLOOK

Nutrition is often a significant factor in studies of taste and smell, and NIDCD will continue to support chemosensory/nutrition research through the Taste and Smell Program.

Because this research is often of trans-NIH relevance, NIDCD will continue to collaborate with other components of NIH.

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NATIONAL INSTITUTE OF DENTAL AND CRANIOFACIAL RESEARCH

https://www.nidcr.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$13,816,475
Nutrition as Percentage of Total IC Obligations for FY21	3.13%

OVERVIEW

The mission of the National Institute of Dental and Craniofacial Research (NIDCR) is to improve dental, oral, and craniofacial health through research, research training, and the dissemination of health information. NIDCR has a diverse portfolio of research related to taste, smell, diet, nutrition, diabetes, obesity, and oral health, including specific research on oral cancer, orofacial clefting, dental caries (cavities), and periodontal disease and the impact of oral disease on diet and nutrition intake. NIDCR supports research on the three underlying components of caries: oral bacteria, the biology of teeth, and the important role of diet and nutrition. Both the types of food consumed and the eating behaviors themselves are key factors in the development of caries. A better understanding of the complexity of influences on oral health—including the role of behavior, diet, and nutrition—will be essential to designing effective strategies and interventions to improve oral health.

RESEARCH DIRECTIONS

Nutrition and Oral Health

- ▶ Influence of fluoride, exposure to sugared beverages, and other dietary factors on caries in adolescents
- ▶ Role of genetics and genomics, diet during infancy and early childhood, and other factors in the development of early-childhood caries in high-risk populations
- ▶ Impact of dietary and behavioral change interventions to reduce sugar-sweetened beverage consumption on prevalence of severe early-childhood caries
- ▶ Development of novel probiotics for the treatment of Sjögren's syndrome and for the control and prevention of dental caries and periodontal disease
- ▶ Roles of dietary components and plant extracts in regulating the inflammatory processes of periodontitis, oral mucosal immunity, and oral manifestations of autoimmunity
- ▶ Mechanisms by which chemical senses (taste and smell) mediate oral and nasal immunity through the oral metabolome
- ▶ Understanding associations among poor oral health, diet, and sarcopenia in older age
- ▶ Developing systematic messaging to reduce consumption of sugar-sweetened foods and beverages among adult residents of public housing
- ▶ Effect of diet, nutrition, and other factors on young adult bone measurements and dental caries
- ▶ Role of vitamin D receptors in the regulation of dentin mineralization
- ▶ Characterization of novel innate immunity factors in human milk and their role in reducing oral HIV transmission via breastfeeding
- ▶ Identification of nutritional biomarkers during pregnancy and genetic variants associated with risk of craniofacial abnormalities
- ▶ Role of the oral microbiome in infants and the impact of childhood obesity-prevention programs on early childhood caries
- ▶ Effect of precision nutrition on dental caries
- ▶ Impact of bariatric surgery on diabetes reversal and the oral microbiome

Microbiology

- ▶ Mechanisms by which the oral bacteria that cause caries coordinate the uptake and metabolism of sugars to maximize their growth and acid production
- ▶ Identification of dietary compounds that may prevent the development of caries by inhibiting harmful biofilm formation while leaving beneficial microbes intact
- ▶ Characterization of the relationship between oral bacteria and obesity
- ▶ Dysbiosis of the subgingival microbiome and its impact on periodontal disease development and progression
- ▶ Interaction between probiotic bacteria, oral microbiota, and oral health promotion
- ▶ Bioactive microbial metabolites involved in microbe–diet–host interactions

Diabetes and Metabolic Syndrome

- ▶ Impact of glycemic control on the integration and survival of dental implants in diabetic patients
- ▶ Mechanistic pathways in the link between type 2 diabetes and periodontal disease
- ▶ The oral microbiome in type 1 diabetes and subclinical CVD
- ▶ The role of metabolic syndrome on the oral microbiome and periodontitis

Oral Cancer

- ▶ Use of vitamin D3 as a dietary supplement to improve the efficacy of an oral cancer treatment
- ▶ Use of plant extracts to prevent and treat oral cancer
- ▶ Development of therapeutics to prevent or treat oral mucositis, a common side effect of chemo-radiation treatment for head and neck cancer
- ▶ Saliva microbiota dynamics and the role in metformin-mediated oral squamous cell carcinoma prophylaxis
- ▶ Identify the therapeutic mechanisms and efficacy of mitochondria-targeted ceramide-analog drug LCL768 in head and neck squamous cell carcinoma (HNSCC) tumor suppression.
- ▶ Investigate the preventive and therapeutic efficacy of bitter melon extract and its active component on head and neck cancer
- ▶ Evaluate microbiome composition with the incidence and time to oral mucositis in head and neck cancer patients treated by chemo-radiation
- ▶ Study hBD-3, an epithelial cell–derived antimicrobial peptide that mediates compositional shifting of the microbiota in cancerous versus noncancerous oral lesions
- ▶ Study the impact of major psychoactive ingredients in chronic marijuana smoking to promote human papillomavirus (HPV) viral persistence at the oropharyngeal mucosae
- ▶ Investigate altered microbiome and microbiota-derived metabolites in the oral cavity to promote HNSCC pathogenesis and immunosuppressive microenvironment
- ▶ Generate a novel immunotherapeutic fusion protein, Albumin-Flt3L, plus *Salmonella* to activate cDC1s and enhance HPV-specific cytotoxic T-cell responses against HPV-associated head and neck cancers

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NATIONAL INSTITUTE OF DIABETES AND DIGESTIVE AND KIDNEY DISEASES

https://www.niddk.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$703,872,514
Nutrition as Percentage of Total IC Obligations for FY21	31.5%

OVERVIEW

Since its creation in 1950, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) research responsibilities have involved nutrition-related research to prevent and treat multiple diseases and disorders, including liver and biliary diseases; pancreatic diseases; gastrointestinal, digestion, and absorption disorders; diabetes; obesity; a variety of endocrine disorders; kidney and urological diseases; metabolic diseases, including cystic fibrosis; and eating disorders. This research is supported by three divisions: the Division of Diabetes, Endocrinology, and Metabolic Diseases (DEM); the Division of Digestive Diseases and Nutrition (DDN); and the Division of Kidney, Urologic, and Hematologic Diseases (KUH). The Office of Obesity Research helps coordinate obesity research across the Divisions and across NIH. Specific programs funding nutrition-related research are listed below:

- ▶ [Clinical and Epidemiological Nutrition Research](#)
- ▶ [Clinical, Behavioral, and Epidemiological Obesity Research](#)
- ▶ [Endocrinology and Hormone Signaling](#)
- ▶ [Gastrointestinal, Nutrition, and Liver Research in HIV/AIDS](#)
- ▶ [Metabolic Pathways](#)
- ▶ [Metabolism, Energy Balance, and Obesity](#)
- ▶ [Nutrient Metabolism, Status, and Assessment](#)
- ▶ [Nutrition and Obesity Genetics and Genomics](#)
- ▶ [Nutrition Obesity Research Centers](#)
- ▶ [Obesity Treatment and Prevention](#)
- ▶ [Obesity, Pregnancy, and the Intrauterine Environment](#)
- ▶ [Diversity and Health Disparities](#)

RESEARCH DIRECTIONS

NIDDK fosters and supports nutrition research and training in multiple areas of basic, epidemiological, and clinical nutrition, as well as nutrition health disparities. Selected topics from the NIDDK nutrition research portfolio include—

- ▶ Studies that examine the effects of nutrient or dietary intake, diet composition, food intake intervals, variation in nutritional status, or interventions on health-related outcomes
- ▶ Development or refinement of methodologies to improve assessment of nutrient intake or status in humans throughout the lifespan, including smart devices for continuous monitoring of circulating nutrients, metabolites and hormones; identification of food-specific molecular profiles and biomarkers of food and nutrient intake and dietary exposure; and analytical methods and modeling to allow the integration of data from a variety of technological approaches
- ▶ Research on the social, cultural, psychological, economic, environmental, and other determinants that influence eating patterns and dietary intake
- ▶ Research on dissemination and implementation of efficacious dietary interventions and investigation of approaches to mitigate nutrition-related health disparities
- ▶ Evaluation of policy- and population-based approaches to improve nutrient/dietary intake or nutritional status.
- ▶ Studies on medical foods and optimal approaches for nutrition support in acute and chronic care for individuals with diseases that fall under the purview of NIDDK
- ▶ Studies that address the regulation of body composition; interactions between nutrition, exercise, and anabolic hormones; neural pathways and neuropeptides that regulate feeding behavior, satiety, and energy expenditure; or better understanding of the physiological mechanisms underlying individual variability in maintenance of reduced weight over time

- ▶ Studies elucidating the absorption, transport, and metabolism of nutrients and the biological control of such processes
- ▶ Investigation of the effects of nutrients in normal and abnormal cellular function and metabolism.
- ▶ Identification of unrecognized roles of nutrients or their metabolites in health and disease
- ▶ Exploration of the impact of dietary modification on the human gut microbiome and dysregulation of the gut microbiome on nutrient absorption, gut barrier function, and permeability and metabolism.
- ▶ Development of swallowable smart pills or devices for precision nutrition, and for studying the microbiome and digestive disease
- ▶ Research to identify genes that influence human nutrition and nutrient metabolism, obesity, and nutritional disorders.
- ▶ Exploration of how dietary modifications affect gene regulation and expression, including relevant nutrigenetic and nutrigenomic approaches
- ▶ Observational and interventional clinical studies (including dietary interventions) on the effects of obesity and gestational/type 2 diabetes during pregnancy on mothers and their offspring beyond the immediate neonatal period.
- ▶ Investigation of the mechanisms by which nutrients might affect renal function
- ▶ Studies to elucidate the endocrine and metabolic basis of wasting in renal failure, HIV infection, liver disease, and other chronic diseases
- ▶ Research to address how food insecurity affects HIV comorbidities, coinfections, and complications
- ▶ Clinical research into nutrition-related areas, such as inborn errors of metabolism, chronic hepatitis, and various liver diseases
- ▶ Studies on the impact of bariatric surgery on health and on the mechanisms by which bariatric surgery may impact food intake, body weight, and obesity-related comorbid conditions

RESOURCES FOR NUTRITION RESEARCHERS

▶ **Conference Support to Advance Nutrition Research**

Agenda: NIDDK supports high-quality conferences that are relevant to the public health and to the scientific mission of NIDDK.

- ▶ **Digestive Diseases Research Core Centers:** Digestive Diseases Research Core Centers generate investigative resources that can be made available to the broader research community. Centers also often support pilot and feasibility programs that fund small grants to generate preliminary data to include in larger grant applications and offer enrichment activities.

▶ **National Centers for Metabolic Phenotyping in Live Models of Obesity and Diabetes (MPMOD):**

The MPMOD Centers provide complex metabolic, physiologic, and behavioral phenotyping and consulting services to characterize living mouse models of obesity and diabetes.

- ▶ **NIDDK Diabetes Centers:** NIDDK Diabetes Centers support research institutions that have an established base of diabetes and related endocrinology and metabolism research by providing increased, cost-effective collaboration among multidisciplinary groups of investigators and shared access to specialized technical resources and expertise. The centers also provide enrichment activities, as well as pilot and feasibility programs that fund small research grants designed to

generate preliminary data for larger grant applications. More information about each Diabetes Center's aims, shared resources, pilot and feasibility programs, enrichment programs, and activities can be found at the main [Diabetes Centers website](#).

- ▶ **Nutrition Obesity Research Centers (NORC):** The NORC program supports 11 centers providing research infrastructure—including research services, pilot and feasibility funding, enrichment programs, and collaborative activities—at academic/medical institutions throughout the United States. The goal of the program is to foster interdisciplinary basic, clinical, and public health research. The NORC program strengthens and provides cost-effective research resources to multidisciplinary groups at institutions with an established, comprehensive research base in nutritional sciences, obesity, and related research topics.

- ▶ **Training and Career Development:** NIDDK training and career development (F, T, and K funding mechanisms) supports nutrition research training in the areas of nutrient metabolism, obesity, and energy regulation.

RESEARCH DISSEMINATION

NIDDK disseminates science-based information on nutrition, diabetes, digestive diseases, obesity, and other topics within its mission. NIDDK health communication experts develop this information to impart to health care providers and the public for the direct benefit of patients and their families. To learn more about the resources provided by NIDDK, visit—

- ▶ **[NIDDK Health Information](#)**: All health information on this site is informed by NIDDK research and reviewed by relevant health professionals. Information is provided to help the general public learn more about diseases and conditions they or loved ones may face. This information is also available in [Spanish](#).

- ▶ **[NIDDK Information for Health Professionals](#)**: NIDDK provides science-based prevention, management, continuing education, and patient education to health professionals in support of care for patients and their families.
- ▶ **[Community Health and Outreach](#)**: This site provides program guides, toolkits, and health fair materials on weight management, diabetes, kidney disease, and other topics for use in the community.

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NATIONAL INSTITUTE ON DRUG ABUSE

https://nida.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$14,517,299
Nutrition as Percentage of Total IC Obligations for FY21	0.9%

OVERVIEW

The National Institute on Drug Abuse (NIDA) mission is to lead the nation in bringing the power of science to bear on drug abuse and addiction. NIDA supports research programs in basic, clinical, and translational sciences in the areas of neuroscience, genetics, medication and behavioral therapies, epidemiology, prevention, and health services, including implementation science and comparative effectiveness research.

RESEARCH DIRECTIONS

NIDA encourages and supports a variety of nutrition-related research in human and animal subjects. Examples of NIDA-funded research and areas of interest include—

- ▶ Whether altered metabolism/mitochondrial function induced by drugs of abuse has a role in the transition to compulsive drug use, ability to remain abstinent, or susceptibility to relapse
- ▶ Whether, and through what mechanisms, developmental exposure, including prenatal exposure, to specific nutrients modifies subsequent vulnerability for substance use disorders
- ▶ Whether, and through what mechanisms, nutritional conditions affecting homeostatic regulation, food restriction, or specific nutrients alter drug taking and relapse to drug taking
- ▶ Understanding the influence of environmental exposures, including drugs of abuse and dietary components, on brain energy utilization in key systems for substance abuse and addiction
- ▶ Studies of nutritional and metabolic disorders in HIV-positive individuals with substance use disorders
- ▶ Studies of the addiction-like effects of highly palatable foods and, conversely, the role of appetite-regulating peptides, such as orexin/hypocretin, leptin, ghrelin, insulin and GLP-1, as potential targets for treating substance use disorders
- ▶ Examining bi-directional interactions between the effects of drugs of abuse on the gut microbiome and microbial effects in the gut–brain axis on motivational and cognitive processes influencing substance use disorders
- ▶ Assessing the biological basis for comorbidity of eating disorders and substance use disorders, including the role of stress hormones and specific neurotransmitter systems
- ▶ Behavioral and neurobiological studies of reward processing and compulsive seeking of food and drug rewards to characterize processes of dysregulated appetitive behaviors
- ▶ Identifying biobehavioral mechanisms underlying appetite changes associated with smoking cessation, including the role of genetic factors and gender differences
- ▶ Determining the prevalence of malnutrition and nutritional risk factors in patients undergoing treatment for substance use disorders
- ▶ Determining if metabolic state influences addiction, i.e., whether drugs of addiction alter the metabolism or nutrient availability in a way that promotes an addicted state or influences craving
- ▶ Understanding the differences and similarities between food reward and drug reward

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NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES

https://www.niehs.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$77,417,359
Nutrition as Percentage of Total IC Obligations for FY21	8.15%

OVERVIEW

The mission of the National Institute of Environmental Health Sciences (NIEHS) is to discover how the environment affects people to promote healthier lives. As an institute, NIEHS is uniquely positioned to investigate the interplay between environmental exposures, human biology, genetics, and common diseases that limit longevity and quality of life.

Research conducted over the past several decades indicates that disease risk is multifactorial, influenced by diverse elements that include exposure to environmental agents—including nutritional sources—and genetic susceptibility. From a pathophysiological standpoint, many environmental exposures affect common biological pathways that are linked to disease, such as oxidative stress and inflammation; these same pathways are likely to be influenced by diet and nutritional status. Thus, variability in disease risk in response to environmental exposures within populations may be at least partially attributable to unmeasured variation in nutritional status or other components of the diet. The NIEHS nutrition research portfolio includes projects aimed at (1) more clearly identifying those dietary components that influence the onset or trajectory of environmentally linked disease and (2) increasing our understanding of the mechanisms underlying the interplay between diet/nutrition and exposure to environmental agents and disease risk. Elucidating those mechanisms underlying these complex interactions will enable the development of effective prevention and intervention strategies to mitigate environmentally induced diseases.

RESEARCH DIRECTIONS

Basic Research

- ▶ Identify pathways during critical life stages where the effects of dietary parameters will have the most pronounced effects on health outcomes.
- ▶ Discover and explain how factors, including diet and medications along with the human microbiome, affect biological systems.
- ▶ Study how the environment, including nutrition, interacts with our genes through genetic and nongenetic mechanisms to help spur breakthroughs in precision health.
- ▶ Use well-established animal models of environmentally induced disease to study the interaction of diet with environmental toxicants.
- ▶ Identify key molecular targets in relevant biologic pathways that could be useful in prevention and intervention studies.
- ▶ Study co-exposures related to food and nutrition to develop novel technological and quantitative approaches to prevent or intervene in adverse health impacts.

Applied Research

- ▶ Expand existing studies to look at the interplay between diet and health outcomes, including secondary data analysis in ongoing studies.
- ▶ Encourage studies to test or develop novel tools or methods of exposure assessment for future studies that will look at diet and environment.
- ▶ Refine and validate dietary assessments for exposure in subpopulations.
- ▶ Add new environmental measures or assays to existing dietary studies.
- ▶ Develop new analytical methods or models to incorporate multiple layers of data (diet and environment).
- ▶ Assess the joint action of multiple environmental insults, including nutritional components, on toxicity and disease, and identify interactions resulting from combined exposures.

- ▶ Continue promoting environment and nutrition research findings to networks of scientists, community advocates, educators, health care providers, and public health officials.

Examples of Nutrition Research Supported by NIEHS

- ▶ How nutrition, exercise, and the environment affect women's reproductive cycles
- ▶ The role of the microbe, including gut microbiota, in regulation of metabolism
- ▶ How a healthy diet may protect against pollution
- ▶ Engineering a small intestinal microbiome to evaluate food additive exposure
- ▶ Mechanistic role of P450 enzymes in the prevention of polycyclic aromatic hydrocarbon (PAH) carcinogenesis by omega-3 fatty acids
- ▶ Developmental polybrominated diphenyl ethers (PBDE) exposure, the gut microbiome, and diabetes
- ▶ Diet, physical activity, and the relationship between air pollution and CVD
- ▶ Health disparities that can lead to both poor nutrition and increased environmental exposures in vulnerable populations
- ▶ Linkages between arsenic exposure, diabetes, and COVID-19 infections and risks in the Navajo Nation
- ▶ Associations between prenatal perfluoroalkyl and polyfluoroalkyl substances (PFAS) mixtures, the metabolome, and cardiometabolic disease in the first 12 years of life
- ▶ Maternal micronutrient status and modification of the health effects from mercury in a multiethnic study
- ▶ Preconception phthalate exposure and offspring outcomes
- ▶ Excess manganese exposure as related to neurogenerative disorders and potential therapeutic intervention for mitochondrial dysfunction

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NATIONAL INSTITUTE OF GENERAL MEDICAL SCIENCES

<https://www.nigms.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$77,721,456
Nutrition as Percentage of Total IC Obligations for FY21	2.2%

OVERVIEW

The principal mission of the National Institute of General Medical Sciences (NIGMS) is to support fundamental research that undergirds all biomedical investigations. The major focus of the institute is on research concerned with expanding knowledge of fundamental biological structure and function at the cellular and molecular levels. Extramural studies supported by the institute include investigations in the biophysical sciences and the physiological sciences, in particular the response of the whole body to trauma; the structure and function of the cell; the basic mechanisms of heredity; and the molecular aspects of the interactions between therapeutic drugs and agents and their target cells, tissues, or organs.

The majority of the nutrition-related research supported by NIGMS is in its trauma and burn injury program area, which focuses on the mechanisms involved in the body's systemic responses to trauma. Thus, research on the role of nutrition in decreasing morbidity rates and morbidity for patients who suffer serious trauma or burn injury is of significant interest to the institute. NIGMS-supported scientists are exploring nutritional requirements following severe trauma and sepsis, new concepts in parenteral therapy, branched-chain amino acid feeding during injury, and cellular function during septic and hemorrhagic shock. In addition, studies are being supported that are investigating the cellular changes and mechanisms responsible for the protein wasting associated with nutritional deprivation.

RESEARCH DIRECTIONS

The following areas of basic research on diseases and traumatic injury are being investigated:

- ▶ The role of diet in organ and cellular responses to cytokines
- ▶ Changes in metabolic patterns and nutritional requirements following severe injury
- ▶ Hormonal imbalance following injury and its effects on metabolism
- ▶ Mechanisms involved in producing a protein catabolic state after injury
- ▶ Adaptive regulation of nutrient transport by the gut; transport appears to be governed by nutrient-receptor proteins on specific cell surfaces
- ▶ Mechanism of suppression of lipoprotein lipase activity by tumor necrosis factor (TNF)
- ▶ Determining components of the host defense system (neutrophils, immunomodulators, etc.) that are important in preventing bacterial translocation
- ▶ Identifying receptors that recognize serum proteins carrying galactosyl sugar residues, including hormones that regulate the rate and extent of nutrient uptake and processing in the liver
- ▶ Interactions between and regulation of arginine, citrulline, ornithine, and urea metabolism following trauma or sepsis
- ▶ Effect of diet on gut microbiome diversity and immune regulation in surgical injury/infection recovery

Research supported by NIGMS serves to establish the foundation of new knowledge needed to make advances in the understanding of biological processes and many diseases. Those investigations that are nutrition-related will help to provide the concepts and relevant information necessary to develop new treatments, particularly in the area of traumatic injury, and thus serve to decrease morbidity and mortality.

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NATIONAL INSTITUTE OF MENTAL HEALTH

https://www.nimh.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$31,775,902
Nutrition as Percentage of Total IC Obligations for FY21	1.6%

OVERVIEW

Created in 1946, the mission of the National Institute of Mental Health (NIMH) is to transform the understanding and treatment of mental illnesses through basic and clinical research, paving the way for prevention, recovery, and cure. NIMH supports biomedical and behavioral research, health services research, research training, and health information dissemination with respect to the causes, diagnosis, treatment, management, and prevention of mental illnesses. As mental health is an important part of overall health, NIMH invests in research on adaptive and maladaptive behaviors to better understand mental function and dysfunction.

RESEARCH DIRECTIONS

NIMH encourages and supports a variety of nutrition-related research areas and projects in human and animal subjects. Examples of NIMH-funded research and areas of interest relevant to nutrition include the following:

- ▶ Exploring the role of the gut microbiome in such mental health conditions as anorexia nervosa, early-life trauma, and depression.
 - ▶ Examining the effect of brain metabolic abnormalities on cognitive function and illness trajectory among individuals at clinical high risk for psychosis.
 - ▶ Using continuous glucose monitoring to detect and intervene on risk and maintenance factors associated with binge-eating psychopathology.
 - ▶ Using remote active and passive data collection technologies and advanced analytic techniques to identify patterns that signal an impending binge or purge episode in individuals with bulimia nervosa or binge-eating disorder.
- By identifying high-risk states, this research has the potential to lay the foundation for personalized precision treatment by alerting and intervening in individuals with eating disorders before an unhealthy behavior, such as binge eating or purging, occurs.
- ▶ Understanding how omega-3 fatty acid docosahexaenoic acid (DHA) traverses the blood-brain barrier to enter the brain. This research is valuable from a basic physiological and biophysical perspective, and it has the potential to aid drug delivery to the brain.
 - ▶ Exploring the effects of maternal obesity and poor antenatal nutrition on offspring cognition, emotion regulation, and risk for neurodevelopmental disorders.
 - ▶ Testing dietary interventions for people with serious mental illness who are overweight or obese to produce clinically significant weight loss and reduce cardiometabolic risk.

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NATIONAL INSTITUTE ON MINORITY HEALTH AND HEALTH DISPARITIES

<https://www.nimhd.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$44,085,247
Nutrition as Percentage of Total IC Obligations for FY21	7.49%

OVERVIEW

Many populations in America—whether defined by race, ethnicity, socioeconomic status, immigrant status, disability, sex, gender, or geography—experience higher rates of certain diseases and deaths than the general population. Although the diversity of the American population is one of the nation's greatest assets, one of its greatest challenges is reducing the profound disparity in health status of its racial and ethnic minority, underserved rural, socioeconomically disadvantaged, and other populations who experience poor health outcomes.

The National Institute on Minority Health and Health Disparities (NIMHD) has been a leader in increasing the scientific community's focus on behavioral, biologic, and environmental factors, including socioeconomics, policies, structural discrimination, culture, and structural social determinants related to health disparities. NIMHD invests in research and fosters collaborations and partnerships to support evidence-based science to inform practice and policy. Its programs and initiatives provide a leading edge in enhancing the scientific knowledge base and designing interventions to improve health outcomes to reduce, and ultimately eliminate, health disparities.

Over the last three decades, the overall health of the nation has improved significantly. However, racial and ethnic minority, less-privileged socioeconomic status (SES), sexual and gender minority, and underserved rural populations continue to experience a disproportionate burden of illness, disability, and premature death. Poor nutrition can affect people for a lifetime and may contribute to health disparities across many populations. Health disparities in CVD, cancer, infant mortality, obesity-associated outcomes, asthma, diabetes, and stroke all may be affected by nutrition.

The prevalence of many chronic diseases—including diabetes, hypertension, CVD, and certain cancers—experienced by African American or Black populations, American Indian and Alaska Native populations, Asian American populations, Native Hawaiian and Pacific Islander populations, and Hispanic or Latino populations is substantially greater than the prevalence of these diseases in white populations. Nutrition and diet-related behaviors also influence these conditions. Neighborhood and other social factors that sustain the existence of food deserts in low-income communities reduce access to food sources that can promote healthier eating. The socioeconomic, environmental, cultural, and structural differences that exist between racial and ethnic minorities and white populations perpetuate these nutrition-related health disparities. Conducting further research to enhance insights into the health determinants associated with these disparities can advance understanding and development of culturally appropriate solutions for these nutrition-related health disparities.

RESEARCH DIRECTIONS

NIMHD supports nutrition research that investigates the causes, treatment, and prevention of diseases disproportionately affecting populations who experience health disparities. The following are selected examples of NIMHD's nutrition-related projects supported during FY20 and FY21.

Addressing the COVID-19 Pandemic

Good Bowls: Empowering Communities to Achieve Good Food Access and Health Equity: Emerging data indicate that those with preexisting health conditions—such as obesity, diabetes, and heart disease—are at significantly increased risk of contracting COVID-19, as are individuals of less-privileged SES and racial and ethnic minority backgrounds. Research

also suggests that food insecurity (i.e., the disruption of food intake or eating patterns because of lack of resources) and poor dietary intake are likely contributors to health disparities in these populations. This research will focus on tailoring the production and distribution of healthy, affordable, locally produced, good-tasting frozen meals to low-income and

minority populations in small towns and rural communities, while also providing economic opportunities for small businesses in rural communities, for application in current COVID-19-impacted regional economies and business environments. The goal is to assist in minimizing the health, financial, and social impacts of the pandemic on populations who experience health disparities. (3R41MD014075-01S1)

The ADELANTE Trial: Testing a Multilevel Approach for Improving Household Food Insecurity and Glycemic Control Among Latinos With Diabetes: Hispanic or Latino individuals account for the largest share of COVID-19 cases (60 percent) and deaths (48 percent) compared to any other racial or ethnic group in California. Additionally, Hispanic or Latino households have experienced a dramatic increase in household food insecurity due to the pandemic. This is especially distressing for Hispanic or Latino individuals with type 2 diabetes because household food insecurity is associated with worse glycemic control during the COVID-19 pandemic. The goal of this study is to determine whether a multilevel intervention to improve household food security and glycemic control is effective for Hispanic or Latino patients with diabetes. Investigators will use a type 1 hybrid trial to assess the effectiveness of the multilevel intervention on the primary outcome of glycemic control (HbA1c) at 6 months. Participants will be randomized to

either 12 weeks of household deliveries of fiber-rich foods or a waitlist control arm, receiving the intervention after a 6-month delay. Investigators will follow participants and will assess the primary outcome of HbA1c at 6 months, as well as such key secondary outcomes as HbA1c at 12 months and diabetes and COVID-related stress at 6 and 12 months. (1R01MD016738-01)

Complex Systems Approaches to Identify Policy Levers to Reduce Racial/Ethnic Disparities in Diet and Obesity in Cities: Researchers will systematically engage local policy, community, and academic stakeholders to develop and refine a dynamic conceptual framework that elucidates drivers of racial/ethnic disparities in diet in cities. Also, an agent-based simulation model will be implemented to examine how high levels of racial/ethnic residential segregation in U.S. cities, the inequitable distribution of food outlets, pervasive income inequality, and the lower price of energy-dense, non-nutritious foods relative to healthier foods work in combination to constrain healthy food choices of racial/ethnic minorities and lead to disparities in diet and obesity. Researchers will use the model to evaluate how inequitable job and income loss due to the COVID-19 pandemic will affect diet disparities, and how multiscale federal, state, and local policies can either exacerbate or reduce disparities. (1R01MD015107-01A1)

Mechanisms and Risk Factors

Maternal Acculturation in Pregnancy and Infant Adiposity in Mexican Americans: This research addresses childhood obesity in the Mexican American population. Epidemiologic observations have consistently documented that individuals of Mexican origin living in the United States exhibit a progressive and pronounced decline in health over time and across generations, warranting considerable concern. The reason for this decline, particularly across generations, is not well understood. This research is studying the cause of intergenerational escalation in obesity among Mexican Americans and whether it begins during the intrauterine period of life. At this time, maternal acculturation-related processes may impact fetal development to produce phenotypic alterations in the structure and function of cells, tissues and organ systems that increase susceptibility for obesity/adiposity. Findings may provide new avenues for early identification of at-risk individuals and directions for the development and testing of prevention and intervention strategies. (5R01MD010738-05)

The COMIDITA Study: Urban Latino Toddlers, Diet Intake, and Developmental Outcomes: Children of recently immigrated Latinos are at increased risk for exposure to multiple social and environmental factors that also contribute to inadequate

nutrient intake, disadvantaging their development. Folate, a key methyl donor critical for DNA synthesis, methylation, and neurodevelopment, can be ingested as naturally occurring food folate or as synthetic folic acid (FA), present in fortified grains and vitamin supplements. Cost and convenience lead to a predominance of fortified foods in accessible staples for poor Latino immigrants. In rodent pups, a postnatal diet of insufficient folate impairs normal neurodevelopment, and diets with excess FA impair short-term memory and behavior. In adult humans, excess FA intake exacerbates memory loss and detrimental cognitive effects of vitamin B12 deficiency. Data examining toddler folate intake and cognition are limited. This research examines whether deficient folate or high folic acid intake at age 24 months lead to poorer cognitive and behavioral test scores at ages 30 and 36 months in children of poor urban Hispanic or Latino immigrants who attend Early Head Start. (5R21MD013622-02)

Role of Pregnane X Receptor in Diet-Induced Obesity and Metabolic Syndrome: Research has shown that the nuclear receptor pregnane X receptor (PXR) is involved in the development of obesity and type 2 diabetes, two complex diseases that disproportionately affect African Americans. This study will explore whether PXR gene variants most common

among African Americans can be linked to obesity and type 2 diabetes and identify the mechanisms linking PXR to these diseases. Data from this study will help to identify treatment targets for obesity and type 2 diabetes. (5U54MD012392-04)

The Influence of Structural Violence and Individual Behavior and Health on the Gut Microbiome and Colorectal Cancer Risk: Among all racial and ethnic groups, African Americans exhibit the highest colorectal cancer incidence and mortality, for reasons that remain poorly understood. The gut microbiome is emerging as a significant contributor to host health and disease. How social determinants interact with individual factors to influence the gut microbiome may be key to understanding racial and ethnic variation in colorectal cancer. This study examines whether exposure to structural violence increases psychosocial and physical vulnerability (e.g., anxiety/stress), compounded by one's behavior (e.g., diet), which interacts with the gut microbiome to result in colorectal cancer health inequality in urban African Americans. (5U54MD012523-04)

The Bariatric Experience Long Term (BELONG) II for Racial and Ethnic Minority Patients: When compared to diet and exercise, bariatric surgery results in much higher weight loss over a period of 24 months (75 percent vs. 11 percent). Racial and ethnic minorities lose less weight following bariatric surgery than whites. Researchers propose to determine how environmental (social, physical) factors, health care system factors, patient psychosocial and behavioral factors, and health status contribute to racial and ethnic disparities in bariatric weight loss and regain after five years. The goal is to understand weight loss and regain for different races and ethnicities five years after surgery. Results will help design

patient-centered, culturally appropriate postoperative care programs so that all patients achieve the maximum benefits from this highly effective treatment. (5R01MD013874-02)

Influence of Dietary Pattern and Race on Metabolic and Epigenetic Alterations Associated With Cancer Development: Dietary patterns impact the metabolome and consequently inflammation, possibly regulating cancer development through alterations in the DNA methylome. This research will examine the independent and combined influences of dietary pattern (vegetarian vs. omnivorous) and race on metabolic and epigenetic alterations, and subsequently, metabolite-methylation associations among healthy participants of the Adventist Health Study-2 cohort. This study will elucidate the role of dietary patterns in cancer disparities and, ultimately, foster the development of effective interventions for cancer prevention. (1K01MD015194-01A1)

Reduction of Risk Factors for Obesity and Linked Chronic Diseases in Native American Employees of the Twin Arrows Casino: Obesity and related diseases present a health crisis among American Indian and Alaska Native populations, of whom 42% are obese and 19.4% have diabetes. Previous studies have shown that a micronutrient-dense, plant-rich (mNDPR) dietary program significantly decreased risk factors for obesity, related chronic diseases, and health care expenditures in multiethnic individuals. This study aims to provide education and exposure to a culturally relevant micronutrient-dense, plant-rich dietary program, with a goal of significantly decreasing risk factors for obesity and related diseases, as well as reducing health care costs, among American Indian and Alaska Native employees. (1R15MD015381-01A1)

Intervention and Translation Research

Developing a Lifestyle Intervention to Reduce Body Weight for Obese African American Men Living in the Rural South: Interventions are needed to address the prevalence of obesity and many obesogenic behaviors among adults living in rural compared to urban areas of the United States. Evidence indicates that men are less motivated than women to lose weight, and these disparities are particularly pronounced for rural African American men, who are largely underrepresented in behavioral weight loss trials in the rural South. This research will show that the theoretically based behavioral weight loss intervention will effectively attract, retain, and motivate rural African American men to engage in healthy weight loss behaviors. (5K23MD013899-03)

A Gender and Culturally Specific Approach to Reduce Non-Alcoholic Fatty Liver Disease (NAFLD) in Mexican American Men: Rates of NAFLD, a modifiable premalignant state associated with hepatocellular carcinoma are highest in the nation for Mexican American men. This grant will support training and research that will utilize a NAFLD-specific weight loss intervention to reduce the burden of NAFLD and improve health outcomes for Mexican American men. (1K01MD014761-01)

Early Life Social, Environmental, and Nutritional Determinants of Disease (ELSEND): Hispanic or Latino individuals are disproportionately affected by multiple chronic diseases that begin in early life, such as obesity, type 2 diabetes, and NAFLD. Understanding and eliminating these disparities is

a national priority given the clinical and public health burden associated with these coexisting chronic diseases. Researchers will examine the contributions of early-life nutrition, exposure

to environmental toxins, and social determinants of health on subclinical markers of chronic disease risk at 5 years of age among Hispanic or Latino children. (1P50MD017344-01)

Prevention

Intervention to Promote Physical Activation and Improve Sleep and Feeding Practices in Infants for Preventing Obesity

Early in Life (The Baby-Act Trial): Infant obesity is increasing in the United States, particularly among Hispanics and Latinos. Rapid weight gain during critical periods of infancy increases the risk of obesity in childhood, continuing into adulthood and increasing the risk of such chronic diseases as diabetes and hypertension. This serious health threat could be prevented through multifaceted interventions during infancy that address multiple risk factors related to physical activity, sleep, nutrition, satiety, and stress and increasing parenting skills associated with early obesity development. The long-term goal of this project is to prevent infant obesity through a structured curriculum that provides a combination of key

messages and activities designed to promote sound parenting skills that support and sustain healthy lifestyle. The proposed intervention is an integrated novel approach leveraging current Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) outreach practices and technology for complementing the current standard of care of the WIC Program. The investigators will assess the clinical effectiveness of this novel complementary intervention among caregivers of infants (0 and 12 months) who are participants of the Puerto Rico WIC program through a cluster-randomized controlled trial in 20 WIC clinics located within the San Juan Metropolitan Area of Puerto Rico. The research plan also includes a detailed evaluation of the cost of the intervention as a modification of the current WIC curriculum. (5U54MD007600-34)

Nutrition Education/Outreach

Osage Community Supported Agriculture Study: American Indians have limited access to healthy food and a high prevalence of diet-related diseases. This study will implement a Tribal community-supported agriculture program in which American Indian adults receive a weekly box of local fresh fruits and vegetables, along with culturally tailored nutrition and cooking education. The program's effect on diet and health outcomes and its cost-effectiveness will be evaluated, and study processes and findings will be broadly disseminated to support Tribes in improving diet and health. (1R01MD016191-01)

prescriptions. This study will test the effects of a culturally sensitive meal planning and affordable grocery delivery service in a randomized controlled trial to improve diet quality, weight control and chronic disease risk among multigenerational Hispanic or Latino households. If this approach proves effective, food prescriptions could provide a scalable and sustainable model to improve diet, health, and well-being in Hispanic or Latino families. (1P50MD017344-01)

Food Prescriptions to Promote Affordable Diets That Meet Recommended Dietary Allowances Among Multigenerational

Latino Households: Hispanic or Latino families are disproportionately affected by obesity, type 2 diabetes, NAFLD, and dyslipidemia. Diet is a major contributing factor, and poor diet is heavily driven by environmental cues. This is especially true in low-income neighborhoods where marketing and availability of unhealthy foods is more salient. One promising approach to address these nutritional, social, and economic contributors to disparities in chronic disease risk is food

Evaluation of a Comprehensive School Nutrition Enrichment Intervention (CSNEI) in Rural School Districts: Rural populations and persons living in low-income households have high rates of obesity. The greatest disparities in obesity prevalence between urban and rural counties are in the southern United States. This research will evaluate a CSNEI in rural schools. The study explores heterogeneity of treatment effects for race and ethnicity, sex, age, and economic status to understand effects on populations most at risk for obesity. This study will fill critical gaps in evidence by rigorously evaluating a CSNEI in rural schools with high proportions of students eligible for free and reduced-price meals. (1P50MD017319-01)

FUNDING OPPORTUNITIES

During this reporting period (FY20 and FY21), the following funding opportunities related to nutrition/diet were offered by NIMHD.

Comprehensive Care for Adults With Type 2 Diabetes Mellitus From Populations With Health Disparities:

The purpose of this funding opportunity announcement (FOA) is to support innovative multidisciplinary, investigative, and collaborative

research focused on developing and testing multilevel or multicomponent strategies, including models of health care, that effectively adapt and implement recommended guidelines of comprehensive clinical care for individuals with type 2

diabetes from populations with health disparities. One of the specific areas of interest included was food insecurity, a core area in the social determinants of health discussed in the PhenX toolkit. (FOA#: PA-21-232)

Administrative Supplements for Research on Dietary Supplements:

This administrative supplement program is designed to provide supplemental funds to relevant, active, NIH-supported research projects to incorporate dietary supplement research that is within the scope of the parent project. Research interests of the Office of Dietary Supplements (ODS) are not limited to specific health conditions, organ systems, or population groups. ODS supports all types of research, including preclinical, clinical, behavioral, and

SCIENCE ADVANCES

The following are examples of science advances on nutritional or dietary related topics by programs funded by NIMHD during FY20 and FY21.

Psychosocial Factors of Diet and Physical Activity Among Rural, Hispanic Children:

Findings From a Multilevel Health Intervention Study: The objective of this research is to examine the relationship of psychosocial factors—such as self-efficacy, family role modeling, and perceptions of the environment—on diet, physical activity, and sedentary behavior in Hispanic or Latino children living in rural Washington state. A subsample of 179 children provided psychosocial measures, diet, and screen time via questionnaire and physical activity via accelerometer. Body mass index percentiles were used to calculate the prevalence of obesity. Prevalence of obesity was 35 percent. Children with obesity consumed one-fifth fewer cups of fruits, 2.2 more teaspoons of total added sugars, and spent 16.1 fewer minutes in moderate-to-vigorous physical activity per day than children with healthy weights. Higher fruit and vegetable self-efficacy scores were associated with more consumption of fruits and vegetables, more engagement in light physical activity, and less time spent sedentary per day. Insight about factors associated with obesity-related behaviors in rural, Hispanic children may help the development of successful and effective behavioral health interventions for this understudied population.

PMID: [31385261](#)

Grant support #: [U01MD010540](#)

Cost-Effectiveness of Nutrition Policies on Processed Meat: Implications for Cancer Burden in the United States:

Processed meats are associated with increased risk of colorectal and stomach cancers, but health and economic impacts of policies to discourage processed meats are not well established. This study aims to evaluate the cost-effectiveness of implementing tax and warning labels on processed meats. A probabilistic cohort-state transition model was developed in 2018, including lifetime and short-term horizons, health

epidemiological. Additionally, ODS supports research that builds future research capacity for studying the role of dietary supplements in health and disease prevention. Primary consideration for support will be given to applications that stimulate dietary supplement research where it is lacking or lagging, clarify gaps, opportunities, and balance between benefits and risks where data are in conflict, emphasize special population groups for whom additional science on supplements is needed, and focus on the use of dietary supplements in improving or maintaining health and reducing the risk of chronic disease. ODS is particularly interested in human studies. (FOA#: PA-20-227)

care, and societal perspectives, and 3 percent discount rates for costs and health outcomes. The model simulated 32 subgroups by age, gender, and race/ethnicity from the U.S. adult population and integrated nationally representative 2011–2014 data on processed meat consumption. In subgroup analyses, greater health and economic benefits accrued to younger subpopulations, subpopulations with greater cancer risk, and those with higher baseline processed meat consumption. The model shows that implementing tax or warning labels on processed meats would be a cost-saving strategy with substantial health and economic benefits. The findings should encourage policymakers to consider nutrition-related policies to reduce cancer burden.

PMID: [31564600](#)

Grant support #: [R01MD011501](#)

Machine Learning With Sparse Nutrition Data to Improve Cardiovascular Mortality Risk Prediction in the United States Using Nationally Randomly Sampled Data:

In this study, researchers aimed to test whether adding nutrition predictor variables or using machine-learning models improves cardiovascular death prediction versus standard Cox models without nutrition predictor variables. In a retrospective study, six waves of NHANES data were collected from 1999 to 2011 and linked to the National Death Index (NDI). The study sample was approximately 20 percent Black or African American and 25 percent Hispanic or Latino. Primary and secondary outcome measures were time from NHANES interview until the minimum of time of cardiovascular death or censoring. A standard risk model excluding nutrition data overestimated risk nearly twofold with moderate discrimination. Nutrition data alone failed to improve performance, and machine learning alone improved calibration to 1.18 and discrimination to 0.91. Results indicate that the inclusion of nutrition data

with available machine learning algorithms can substantially improve cardiovascular risk prediction.

PMID: [31784446](#)

Grant support #: [DP2 MD010478](#)

Development and Application of a Total Diet Quality Index for

Toddlers: This study aimed to create a diet quality index based on a scoring system for ages 12 to 23.9 months, the Toddler Diet Quality Index (DQI), and evaluate its construct validity using 24-hour dietary recall data collected from a national sample of children from the Feeding Infants and Toddlers Study (FITS) 2016. The mean Toddler DQI was 49 out of 100 possible points, indicating room for improvement. Toddlers under-consumed seafood, greens, beans, and plant proteins and over-consumed refined grains and added sugars. Toddler DQI scores were higher among children who were ever breastfed, lived in households with higher incomes, and who were Hispanic. The Toddler DQI performed as expected and offers a measurement tool to assess the dietary quality of young children in accordance with federal nutrition guidelines. This is important for providing guidance that can be used to inform public health nutrition policies, programs, and practices to improve diets of young children.

PMID: [34198828](#)

Grant support #: [U54MD012530](#)

Association of Magnesium Intake and Vitamin D Status With Cognitive Function in Older Adults: An Analysis of U.S.

NHANES 2011 to 2014: Reduced cognitive function associated with aging has gained increasing attention as the U.S. population ages. Magnesium plays a critical role in vitamin D biosynthesis and metabolism, and deficiencies in magnesium and vitamin D show associations with poor cognition. However, no study has examined their interaction. This study aimed to evaluate the associations of magnesium intake and serum 25-hydroxyvitamin D (25(OH)D) concentrations, indicating vitamin D status, with cognition, and interaction between these nutrients in older adults. Based on the NHANES 2011–2014, the study included 2,466 participants age 60 or older who completed the Digit Symbol Substitution Test (DSST). Higher total magnesium intake was independently associated with higher DSST scores. The association of total magnesium intake with high DSST score was primarily observed among women, white individuals, physically active participants, and those with sufficient vitamin D status, although the interactions were not significant. Findings suggest that high magnesium intake alone may improve DSST scores in older adults, and the association may be stronger among subjects with sufficient vitamin D status.

PMID: [32388734](#)

Grant Support #: [U54MD006882](#)

COVID-19-Related Food Insecurity Among Households With

Dietary Restrictions: A National Survey: Food insecurity increased because of the COVID-19 pandemic; however, little is known about pandemic-related food insecurity in households with dietary restrictions. This study aims to examine pre-pandemic rates and pandemic-related change in food insecurity among households with and without dietary restrictions such as food allergies or celiac disease. Pre-pandemic food insecurity and early pandemic-related change in food insecurity were assessed using the adapted Hunger Vital Sign. Weighted, multivariate logistic regression was used to model the odds of pre-pandemic food insecurity and the odds of incident or worsening pandemic-related food insecurity among households with and without dietary restrictions. Before the COVID-19 pandemic, households with self-reported food allergy, celiac disease, or both were significantly more likely to be food insecure than households without restrictions. Households with dietary restrictions were also significantly more likely to experience incident or worsening food insecurity during the early pandemic. Race/ethnicity was not a significant moderator of the relationship between dietary restrictions and pandemic-related food insecurity. Households with dietary restrictions were more likely to experience both pre-pandemic and pandemic-related incident or worsening food insecurity than households without restrictions. Clinical care for patients with dietary restrictions requires attention to food insecurity.

PMID: [34174493](#)

Grant support#: [R01 AG064949](#)
[R01 MD012630](#)

The Early Effects of Cumulative and Individual Adverse Childhood Experiences on Child Diet:

Examining the Role of SES: Adverse childhood experiences (ACEs) have been associated with detrimental long-term health outcomes, including obesity risk. Existing research has yet to examine whether early life ACEs are associated with diet in early childhood within socioeconomic subgroups. For this study, data were drawn from the Early Childhood Longitudinal Study-Birth Cohort (2001–2002). Mother-child dyads were recruited when children were 9 months old and followed longitudinally at 2 years and 4 years. Mothers reported children's exposure to five ACEs at 9 months and 2 years and children's daily intake of fruits, vegetables, sweet snacks, and sugar-sweetened beverages at 4 years. Results provide preliminary evidence on the association between cumulative and specific ACEs and child diet, and how this relationship varies by SES context. Future research is needed to understand the complex multilevel mechanisms operating along this pathway to

inform interventions supporting behavior change and to build evidence for policies that may reduce diet-related disparities in ACE exposure.

PMID: [33545230](#)

Grant support #: [K01 MD015326](#)

[K23 HD101554](#)

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NATIONAL INSTITUTE OF NEUROLOGICAL DISORDERS AND STROKE

https://www.ninds.nih.gov	
Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$31,498,709
Nutrition as Percentage of Total IC Obligations for FY21	1.2%

OVERVIEW

Created in 1950, the mission of the National Institute of Neurological Disorders and Stroke (NINDS) is to seek fundamental knowledge about the brain and nervous system and to use that knowledge to reduce the burden of neurological disease. NINDS conducts, fosters, coordinates, and guides basic, translational, and clinical neuroscience research on the causes, prevention, diagnosis, and treatment of neurological disorders and stroke. NINDS also funds training and career development programs to nurture a talented and diverse neuroscience research workforce and communicates scientific discoveries and their implications for neurological health to the public, health professionals, researchers, and policymakers.

RESEARCH DIRECTIONS

Rapid and recent progress in brain research has yielded new understanding of the interaction between nutrition and the nervous system. In FY20, about 90 projects supported by NINDS were categorized as nutrition research projects. Many of these projects are mechanistic studies that investigate the role of nutrients or metabolic processes in neurological conditions or in healthy neurons with the goal of discovering novel therapeutic targets for neurological disorders. Major areas of research and highlights of NINDS-supported nutrition research during FY20 and FY21 include the following:

- ▶ Basic research studies that examine the role of nutrients in brain health and development and a variety of neurological disorders and brain injury, including cerebrovascular disease, cerebellar ataxia, multiple sclerosis, and traumatic brain injuries
- ▶ Mechanistic studies that investigate metabolic processes to better understand how cellular energy metabolism affects brain function, with the goal of identifying novel therapeutic approaches for neurological diseases
- ▶ Translational research studies that test dietary interventions or metabolic pathway-targeting molecules in animal models of neurological diseases, including pain conditions, ischemic stroke, Huntington's disease, neural tube defects, and epilepsy
- ▶ Studies that explore the role of the gut microbiome in Parkinson's disease, brain injuries, multiple sclerosis, epilepsy, and central nervous system autoimmunity and aim to understand how the gut microbiome—often influenced by nutrition and diet—may modulate the immune system and neural function
- ▶ Mechanistic studies that examine how altered metabolism or obesity may contribute to impaired neural function, including projects that aim to understand molecular mechanisms underlying obesity-related memory deficits and obesity-induced remodeling of the brain vasculature
- ▶ Research projects focused on comorbid conditions, such as stroke in obese individuals or stroke in individuals with metabolic syndrome
- ▶ A multidisciplinary clinical research project that is testing whether stimulation of the brain circuitry thought to be involved in loss-of-control eating may be an effective intervention strategy for binge eating

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NATIONAL INSTITUTE OF NURSING RESEARCH

<https://www.ninr.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$20,174,680
Nutrition as Percentage of Total IC Obligations for FY21	12.4%

OVERVIEW

The mission of the National Institute of Nursing Research (NINR) is focused on leading nursing science to solve pressing health challenges and inform practice and policy, optimizing health and advancing health equity into the future. NINR-supported research is innovative; applies the most rigorous methods; advances equity, diversity, and inclusion; tackles today's pressing health challenges; and stimulates discoveries to prepare for, prevent, and address tomorrow's challenges. NINR-supported science seeks to discover solutions to optimize health across clinical, community, and policy settings. More information can be found in the [NINR 2022–2026 Strategic Plan](#).

RESEARCH DIRECTIONS

NINR views nutrition as an essential component of prevention and health promotion. Good nutrition is impacted by the social determinants of health, a primary focus area of NINR research. Nutrition is a topic of particular interest in NINR's population and community health research and a key factor in improving health equity. The nutrition research portfolio at NINR spans the spectra of disease, populations, and the lifespan.

Recent examples of NINR research efforts in these areas include studies focused on the following activities:

- ▶ Addressing infant and child obesity through family- and community-based participatory research on culturally tailored interventions for healthy eating in underserved populations²³
- ▶ Utilizing uniquely integrated nutrition and math curricula to improve food-buying behaviors of children in urban areas²⁴
- ▶ Employing e-health and mHealth approaches to provide personalized dietary management of gestational weight in low-income mothers²⁵ and in individuals with type 2 diabetes²⁶ and, in response to the COVID-19 pandemic, adapt existing nutritional interventions provided by community-based congregate meal programs to use in digital nutrition programs aimed at older adults who lack technological expertise²⁷

NINR has co-sponsored several nutrition-related FOAs to promote research into the development and testing of innovative interventions to reduce risk factors associated with nutrition. For example, NINR sponsored [PA-18-776](#), "Maternal Nutrition and Pre-Pregnancy Obesity: Effects on Mothers, Infants, and Children," which encouraged R01 applications to improve health outcomes for women, infants, and children by stimulating interdisciplinary research focused on maternal nutrition and pre-pregnancy obesity. NINR also supported [PA-18-355](#), "Healthy Habits: Timing for Developing Sustainable Healthy Behaviors in Children and Adolescents," which encouraged applications that employ innovative research to identify mechanisms of influence or promote positive sustainable health behavior(s) in children and youth (birth to age 21). Last, NINR supported [PAR-18-857](#), "Diet and Physical Activity Assessment Methodology," which encouraged innovative research to enhance the quality of measurements of dietary intake and physical activity.

These studies highlight NINR's long-term commitment to nutrition research that promotes community and population health and supports family- and community-based solutions to improve health outcomes and equity.

²³ R01NR015417 Back to Basics: Addressing Childhood Obesity Through Traditional Foods in Alaska; R01NR016255 Rural Disparities in Pediatric Obesity: The iAmHealthy Intervention; R01NR017199 Healthy Mothers-Healthy Children: An Intervention with Hispanic Mothers and their Young Children; R21NR019126 Reducing Health Disparities through an Adaptive Healthy Eating Program for Underserved Infants in a Home Visiting Program.

²⁴ R01NR017571 Effect of an integrated nutrition-math curriculum to improve food-purchasing behavior of children.

²⁵ R01NR017644 A pragmatic, scalable e-health intervention for management of gestational weight gain in low-income mothers.

²⁶ R01NR018916 Personalized Dietary Management in Type 2 Diabetes.

²⁷ R01NR020303 A Technological Intervention to Improve Nutrition among Older Adult Congregate Meal Participants during COVID-19.

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OFFICE OF DIETARY SUPPLEMENTS

<https://ods.od.nih.gov>

Nutrition Research Spending for Fiscal Year 2021 (FY21)	\$8,766,181
Nutrition as Percentage of Total Office Obligations for FY21	32.3%

OVERVIEW

The mission of the Office of Dietary Supplements (ODS) at NIH is to strengthen knowledge and understanding of dietary supplements by evaluating scientific information; stimulating and supporting research; disseminating research results; and educating the public to foster an enhanced quality of life and health for the U.S. population.

Dietary supplements are widely used in the United States by people who want to maintain or improve their health or reduce their risk of illness. In 2020, Americans spent more than \$56 billion on more than 80,000 products containing vitamins and minerals, herbs and botanicals, and other ingredients, such as glucosamine, fish oils, and probiotics.

The Dietary Supplement Health and Education Act (DSHEA) of 1994 defined dietary supplements as products intended to supplement the diet. DSHEA also established ODS at NIH in HHS; ODS began operations in November 1995; its acting director is Joseph M. Betz, Ph.D.

Scientists are studying dietary supplements to determine their value in maintaining good health. ODS supports this research to assess the benefits and risks of dietary supplements and communicates the results of this research to scientists, health professionals, and consumers.

EXAMPLES OF ODS ACTIVITIES

Research Support

The majority of the ODS budget supports research on dietary supplements in collaboration with many NIH ICs. For FY21, ODS provided \$10.6 million in co-funding 61 grants across 12 NIH ICs. Since its inception, ODS has funded hundreds of conferences, workshops, and meetings on dietary supplements that help inform and direct research efforts for ODS and NIH. Further information is available on the ODS [Grants and Funding](#) webpage.

Centers for Advancing Research on Botanical and Other Natural Products (CARBON) Program: Since 1999, in partnership with NCCIH, ODS has funded multidisciplinary centers to study the health effects of botanicals at academic research institutions across the United States. These centers identify and characterize botanical ingredients; assess their biological activity and bioavailability; evaluate their effects in cells, animals, and people; help select botanicals to test in clinical trials; and provide a rich environment for training and career development.

Analytical Methods and Reference Materials: More than 80,000 dietary supplements are estimated to be available in the U.S. marketplace, but in many cases, reliable analytical methods are not available to assess the quality of their ingredients. This ODS initiative enhances collaborative efforts

to develop and validate analytical methods and develop reference materials for commonly used dietary supplements.

Training and Career Development: ODS provides support for postdoctoral students and scientists at universities across the United States, as well as in government agencies. This program's goal is to expand the number of well-qualified researchers who investigate dietary supplements, with an emphasis on training young investigators, minorities, and women. Program components include the [ODS Research Scholars Program](#) and the [Mary Frances Picciano Dietary Supplements Research Practicum](#).

Population Studies Program: The Population Studies Program evaluates the use of dietary supplements by the U.S. population and specific population subgroups and the contributions that dietary supplements make to nutritional status. Research is focused on describing the use of dietary supplements, including specific supplements taken, amount consumed, and duration of use. This program uses data from nationally representative surveys and other large population-based studies to conduct research and characterize emerging issues, such as changing patterns in use of these products. Staff also lead efforts to address methodological issues in assessing dietary and dietary-supplement intakes in epidemiological and other large studies.

Iodine Initiative: Iodine is an essential nutrient and a component of thyroid hormone. The iodine status (i.e., adequacy or deficiency) of populations and individuals varies with local geographic features, availability in the food supply, and use of fortified foods and dietary supplements. Although iodine deficiency is rare in the United States and Canada, it can have serious effects. ODS developed its Iodine Initiative in 2011 in response to concerns that some pregnant women may have

inadequate intakes of this nutrient at a time of high physiologic demand. Five workshops have provided ODS expert opinion on public health issues and research needs. ODS activities in iodine nutrition focus on supporting research, methodology development, and research-related resources that can provide a scientific base for understanding how best to improve iodine status in individuals with low to moderate risk of deficiency.

Dietary Supplement Ingredient and Label Databases

- ▶ The [Dietary Supplement Ingredient Database \(DSID\)](#), developed by the U.S. Department of Agriculture (USDA) Nutrient Data Laboratory in collaboration with ODS and other federal agencies, provides estimated levels of ingredients in dietary supplement products sold in the United States. The DSID is intended primarily for research applications.
- ▶ The [Dietary Supplement Label Database \(DSLID\)](#), a collaborative project of ODS and the National Library of Medicine, contains information taken from the labels of approximately 100,000 dietary supplement

products available in the U.S. marketplace. Each month approximately 1,000 labels are added to the DSLID.

- ▶ The [Computer Access to Research on Dietary Supplements \(CARDS\)](#) database contains federally funded research projects pertaining to dietary supplements. Currently, CARDS contains projects funded by the ICs beginning with FY99, the first year that NIH ICs began reporting research related to dietary supplements. Projects funded by other federal agencies are added to CARDS as they become available; partial data from the USDA and the U.S. Department of Defense are available.

Communications

ODS develops and disseminates information about the latest science on dietary supplements for a wide range of audiences, including researchers, health care providers, industry, and consumers. This information is provided through the ODS

website, fact sheets, newsletters, and staff presentations at professional and consumer-focused meetings, as well as the [ODS listserv](#).

Information Resources on Dietary Supplements

ODS makes accurate and up-to-date scientific information about dietary supplements available to researchers, health care providers, and the public, through the following resources:

- ▶ [Dietary Supplement Fact Sheets](#): These overviews of dietary supplement ingredients (including vitamin D, omega-3 fatty acids, and weight-loss supplements) are written for varied audiences, including researchers, health care providers, and consumers. Consumer fact sheets are also available in Spanish.
- ▶ [PubMed Dietary Supplement Subset](#): The subset is designed to limit search results to citations from a broad spectrum of dietary supplement literature including vitamin,

mineral, phytochemical, ergogenic, botanical, and herbal supplements in human nutrition and animal models.

- ▶ [CARDS](#): This searchable database provides information on federally funded research projects pertaining to dietary supplements.
- ▶ [DSID](#): This database provides the amount of nutrients in some dietary supplements based on chemical analysis.
- ▶ [DSLID](#): This database contains information taken from the labels of the dietary supplement products available in the U.S. marketplace.

ODS Newsletters

ODS distributes three [electronic publications](#) through the ODS listserv:

- ▶ *ODS Update*, sent out periodically, includes news about ODS programs, staff publications and presentations, dietary supplement fact sheets, databases, meetings, and exhibits.

- ▶ *The Scoop*, a consumer-focused e-newsletter, is sent out several times a year. Each issue has a slightly different theme, such as multivitamins or dietary supplements and aging.
- ▶ ODS informs the listserv about timely announcements through the *Special Supplement*.

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Appendix A

Appendix A: NIH RePORT and RePORTER Search Methodology

ABOUT NIH RePORT AND NIH RePORTER

In addition to carrying out its scientific mission, NIH exemplifies and promotes the highest level of public accountability. To that end, the RePORT website provides access to reports, data, and analyses of NIH research activities, including information on NIH expenditures and the results of NIH-supported research.

One tool available on the RePORT website is the RePORTER module. RePORTER is an electronic tool that allows users to search a repository of intramural and extramural NIH-funded research projects and access publications and patents resulting from NIH funding.

In addition to RePORTER, the RePORT website also contains other tools that provide access to reports and summary statistics on NIH funding and the organizations and researchers involved in NIH research and training. One tool is the NIH Data Book, which summarizes the most commonly asked questions about the NIH budget and extramural programs. Another tool is Awards by Location, which summarizes NIH awards for a particular fiscal year by the location and organization of the awardees.

As described in the NIH Reform Act of 2006, Congress requires NIH to report annual spending for more than 300 research, condition, and disease categories, including nutrition. Historically, projects related to nutrition were identified by staff in each of the institutes and centers (ICs). However, at the request of Congress, NIH developed an improved process to provide better consistency and transparency in the reporting of its funded research. In Fiscal Year 2008, NIH began using the Research, Condition, and Disease Categorization (RCDC) system to define the more than 300 categories for which NIH reports

SEARCH METHODOLOGY

The [RePORT](#) database was used to calculate total funding for Nutrition Research by NIH ICO using the Research, Condition, and Disease Categorization (RCDC) code “Nutrition” under Categorical Spending. “Categorical Spending displays the annual support level for various research, condition, and disease categories based on grants, contracts, and other funding mechanisms used across the NIH, as well as disease burden data.”

Total funding in nutrition (nutrition research and training current dollars) restricted to Fiscal Years 2019, 2020, and 2021 (FY19, FY20, FY21, respectively) was the sum of nutrition

annual spending to Congress and the public. The RCDC uses sophisticated text data mining in conjunction with NIH-wide definitions to match projects to research spending categories.

The definitions (fingerprints) are a list of terms and concepts selected by NIH scientific experts to define a research category. The nutrition fingerprint was created by NIH staff and nutrition science experts representing several NIH ICs. It was developed based on the Interagency Committee on Human Nutrition Research’s definition of human nutrition research: *the pursuit of new knowledge to improve the understanding of nutrition as it relates to human health and disease and, as here defined, encompasses studies in five major areas—biomedical and behavioral sciences, food sciences, nutrition monitoring and surveillance, nutrition education, and impact on nutrition and intervention programs and socioeconomic factors*. The fingerprint is compared to each NIH-funded research project by searching titles, abstracts, and specific aims to generate a list of research projects related to nutrition. Because there is no reasonable way to assign a percentage of the project as relevant to nutrition, the dollars for all identified nutrition-related projects are counted as 100 percent nutrition. Research projects may meet the criteria of multiple fingerprints, and most nutrition projects are categorized under other spending categories, as well. For example, a project that meets the criteria for the nutrition, obesity, and prevention fingerprints would be included in each of the respective RCDC categories, so adding the number of projects or dollars in each category would result in a number that far exceeds the total number of projects or dollars.

research and training current dollars plus subproject funding ([Table 1](#)). The total nutrition research and training in current dollars by NIH component for FY19, FY20, and FY21 is provided in [Table 2](#). Nutrition research and training in constant dollars was calculated using the [Biomedical Research and Development Price Index](#) ([Table 1](#)). Nutrition research and training in constant dollars for FY20 and FY21 was calculated by setting FY19 as 100 percent and taking this amount and dividing it by 1.017 and 1.039 for FY20 and FY21, respectively ([Table 1](#)). The actual total NIH obligations and IC obligations for FY19, FY20, and FY21 were obtained from the NIH Budget

Office [Actual and Total Obligations by Institute and Center history tables](#) (Tables 1 and 3). Constant nutrition dollars as a percentage of actual total NIH obligations by fiscal year (Table 1) was calculated by taking the nutrition and research training constant dollars and dividing that value by actual total NIH obligations and multiplying the result by 100.

Figure 1 shows the percentage of nutrition research and training projects that overlap with other spending categories. The RePORTER database was used to calculate the overlapping spending categories as a percentage of total funded projects in nutrition. The RCDC categories “nutrition” and “overlapping category” (e.g., prevention, obesity, cancer, microbiome) were used as Boolean terms to compute funding for those overlapping categories. The total number of projects is the

sum of total funding plus subproject funding. Actual total NIH obligations were used to calculate the percentage of nutrition research and training current dollars, both for funding and number of projects.

Nutrition funding percentage by NIH research mechanism (Figure 2) was computed using the RePORTER tool and categorizing the search by funding mechanism. The RCDC term “nutrition” was used and restricted to FY19, FY20, and FY21. The training categories (individual and institutional) were grouped into a single “training” category, and other research-related, Small Business Innovation Research/Small Business Technology Transfer, and interagency agreements were grouped into the “other” category.

Appendix B

Appendix B: Acronyms for NIH Institutes, Centers, and Offices

FIC	Fogarty International Center
NCATS	National Center for Advancing Translational Sciences
NCCIH	National Center for Complementary and Integrative Health
NCI	National Cancer Institute
NEI	National Eye Institute
NHGRI	National Human Genome Research Institute
NHLBI	National Heart, Lung, and Blood Institute
NIA	National Institute on Aging
NIAAA	National Institute on Alcohol Abuse and Alcoholism
NIAID	National Institute of Allergy and Infectious Diseases
NIAMS	National Institute of Arthritis and Musculoskeletal and Skin Diseases
NIBIB	National Institute of Biomedical Imaging and Bioengineering
NICHD	<i>Eunice Kennedy Shriver</i> National Institute of Child Health and Human Development
NIDA	National Institute on Drug Abuse
NIDCD	National Institute on Deafness and Other Communication Disorders
NIDCR	National Institute of Dental and Craniofacial Research
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases
NIEHS	National Institute of Environmental Health Sciences
NIGMS	National Institute of General Medical Sciences
NIMH	National Institute of Mental Health
NIMHD	National Institute on Minority Health and Health Disparities
NINDS	National Institute of Neurological Disorders and Stroke
NINR	National Institute of Nursing Research
NLM	National Library of Medicine
OD	Office of the Director
ODS	Office of Dietary Supplements

Appendix C

Appendix C: Acknowledgments

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