

# NIH Nutrition Research Report 2017 - 2019



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# NIH NUTRITION RESEARCH REPORT, 2017 - 2019

# I. EXECUTIVE SUMMARY

Each year, the National Institutes of Health (NIH) funds a broad array of basic and applied research studies to further our understanding of nutrition as it relates to human health and disease. This includes research related to how nutrients and food components are ingested, digested, absorbed, metabolized, transported, stored, and excreted and the overall impact on the body as well as the study of the environment, psychology, and behavior associated with eating and how these factors play a role in nutritional status and in which foods people choose to consume.

This Report summarizes NIH nutrition research activities in Fiscal Year (FY) 2017-2019 and builds on an earlier publication summarizing nutrition research activities in FY 2015 and FY 2016. The Report was compiled by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) Office of Nutrition Research (ONR), located within the NIDDK Director's Office. The ONR serves as a point of contact for nutrition research coordination by helping to lead NIH-wide strategic planning and the development of nutrition research initiatives.

The NIH leads all federal agencies in funding nutrition research and training. The total NIH investment in nutrition-related research was approximately \$1.7 billion in FY 2017, \$1.8 billion in FY 2018, and \$1.9 billion in FY 2019. The NIDDK; National Heart, Lung, and Blood Institute (NHLBI); National Institute on Aging (NIA), and National Cancer Institute (NCI) lead the NIH Institutes and Centers (ICs) in nutrition research funding. In FY 2019, their nutrition-related funding was \$635 million, \$249 million, \$172 million and \$155 million respectively. Approximately half of the nutrition-related projects in FYs 2017-2019 were related to Prevention and/or Obesity.

NIH-supported nutrition research has led to important discoveries. Many of these findings are announced in NIH News Releases or are 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 2017-2017 include:

- Moderately reducing caloric intake over a period of two years significantly improved cardiometabolic risk factors in young and middle-aged, non-obese adults, according to new findings from the Comprehensive Assessment of Long-term Effects of Reducing Intake of Energy (CALERIE) trial. (read more)
- In a small-scale, randomized controlled trial examining the effects of ultra-processed foods as defined by the NOVA classification system, people eating ultra-processed foods ate more calories and gained more weight than when they ate a minimally processed diet. (read more)

Research funded by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) and the National Institute of Allergy and Infectious Diseases (NIAID) provides a possible explanation for why iron can sometimes worsen malaria infection. Researchers found that extra iron interferes with ferroportin, a protein that prevents a toxic buildup of iron in red blood cells and helps protect these cells against malaria infection. They also found that a mutant form of ferroportin that occurs in African populations appears to protect against malaria. These basic findings may help researchers and healthcare officials develop strategies to prevent and treat malaria infections, which numbered nearly 216 million worldwide in 2016. Read more

During 2017-2019, the NIH sponsored numerous nutrition-related scientific meetings, workshops, and symposiums. These events play a key role in the advancement of nutrition science by providing an opportunity to identify critical research gaps and disseminate research findings to the scientific community and to the public.

Trans-NIH, government-wide, and public-private partnership collaborations were critical to the development of numerous nutrition research, strategic planning, and technology transfer initiatives during 2017–2019. These collaborations are critical to effectively utilize resources and harmonize the federal nutrition research agenda. Examples include the Interagency Committee on Human Nutrition Research (ICHNR), the National Collaborative on Childhood Obesity Research (NCCOR), and the NIH Nutrition Research Task Force (NRTF).

The NIH is committed to fostering innovative research and training to advance the field of nutritional science with the goal of protecting and improving health. Each NIH IC plays an integral role in accomplishing this mission, and they have shared their research directions as they pertain to nutrition. The ONR hopes this comprehensive report is not only informative but also serves 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. The NIH is made up of 27 institutes and centers (ICs), each with a specific research agenda that often focuses on diseases or body systems. The NIH supports biomedical 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 is an integral part of overall health, development, and wellbeing. As a result, research interests in the nutritional sciences extend far beyond those of a single institute. Biomedical nutrition research and training in 2017-2019 was supported by 24 NIH ICs, the NIH Office of the Director (OD) and the National Library of Medicine (NLM).

The NIH nutrition research portfolio includes extramural and intramural research as well as research training. Ninety-five percent (95%) of the portfolio is extramural research, carried out at hundreds of institutions across the globe. Many of the research projects funded by the NIH are based on ideas developed and submitted by individual investigators, principally from institutions of higher education (81%), independent hospitals (9%) and other research organizations (6%). Most of the intramural research is carried out in laboratories on the NIH campus in Bethesda, Maryland, and at the Warren Grant Magnuson Clinical Center, although several ICs also have off-campus programs located throughout the country.

# **III. OFFICE OF NUTRITION RESEARCH**

The NIDDK Office of Nutrition Research (ONR) is responsible for leadership of nutrition research at NIDDK and coordination of nutrition research across NIH Institutes, Centers, and Offices. The ONR participates in strategic planning, portfolio analysis, budget and resource allocation, and assessment of research needs and opportunities that fall within the mission of NIDDK and the NIH. Strategic planning includes developing new NIH initiatives in nutrition research. ONR acts on behalf of NIH as an interagency point of contact for nutrition research.

One of the ONR's primary tasks is to lead the development and implementation of an NIH-wide strategic plan for nutrition research by working with the NIH Nutrition Research Task Force (NFTF) to accomplish this goal. The NRTF is chaired by Dr. Griffin P. Rodgers, director of the NIDDK. Co-chairs are Dr. Gary Gibbons, director of the National Heart, Lung, and Blood Institute (NHLBI); Dr. Norman Sharpless, director of the National Cancer Institute (NCI); and Dr. Diana W. Bianchi, director of the Eunice Kennedy Shriver National Institute of Child Health and Human Development. Participants on the NRTF represent these and other institutes, centers, and offices. Dr. Christopher Lynch, Director of NIDDK's Office of Nutrition Research, serves as the Task Force Executive Secretary. The ONR and NRTF work together to coordinate and accelerate progress in nutrition research across the NIH.

# IV. NIH NUTRITION RESEARCH AND FUNDING

#### **Overview**

The NIH is the leader in federally supported nutrition research and training. In FY 2017 -2019, the NIH provided \$1.71, \$1.83 and \$1.93 billion respectively in financial support for nutrition research and training. This represents the combined individual contributions of 24 NIH ICs, the NIH OD and the National Library of Medicine. In FY 2017-2019, the NIH funded nutrition research in 50 states, 2 territories, the District of Columbia, and 15 foreign countries. NIH supported just under 500 nutrition-related clinical trials in FY 2019.

### **Human Nutrition Research Reporting**

The FY 2017-2019 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) Expenditures and Results (RePORTER) System.

#### About RePORTER

RePORTER is an electronic tool that allows users to search a repository of both intramural and extramural NIH-funded research projects from the past 25 years and access publications (since 1985) and patents resulting from NIH funding. Although not included in this Report, in addition to NIH-funded research, RePORTER provides access to research supported by the Centers for Disease Control and Prevention, the Agency for Healthcare Research and Quality, the Health Resources and Services Administration, the Substance Abuse and Mental Health Services Administration, and the U.S. Department of Veterans Affairs. The Federal RePORTER system, launched in September 2014, was developed based on the NIH RePORTER.

As described in the 2006 NIH Reform Act, Congress requires the NIH to report annual spending for over 200 research, condition, and disease categories, including nutrition. Historically, projects related to nutrition were identified by staff in each of the NIH ICs. However, at the request of Congress, the NIH embarked on a process to provide better consistency and transparency in the reporting of its funded research. Beginning with FY 2008, the NIH began using the Research, Condition, and Disease Categorization (RCDC) system to define the more than 200 categories which the NIH reports annually to Congress and the public. RCDC uses sophisticated text data mining in conjunction with NIH-wide definitions used 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 NIH Nutrition Fingerprint is based on the Interagency Committee on Human Nutrition Research (ICHNR) 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, and was created by NIH staff working in conjunction with nutrition science experts representing many NIH ICs. The Fingerprint is compared to each NIH funded research project by searching titles, abstracts, and specific aims to generate a list of research projects which are nutritionrelated. As there is no reasonable way to assign a percent nutrition using the Nutrition Fingerprint, the dollars for all identified nutrition-related projects are counted as 100% nutrition. Research projects may meet the criteria of multiple fingerprints, and most nutrition projects are categorized under other spending categories as well. In other words, a project may be counted as nutrition, obesity, and prevention, and it would be counted once in each category, so adding the number of projects, or dollars, in each category would far exceed the total number of projects.

#### **Nutrition Research and Training Expenditures**

#### Trends: FY 2015-2019

As a percentage of total NIH spending, nutrition research funding has been stable at approximately 5% for many years. Table 1 shows total NIH biomedical nutrition research and training support in current, as well as constant dollars. Actual obligations for nutrition research and training by NIH ICs during FY 2015-2019 are shown in Table 2. NIDDK, NHLBI, and NIA led NIH spending in nutrition-related research in FY 2019. For the first time, NCI was not one of the top three funders of nutrition research. In FY 2019, nutrition spending by NIDDK, NHLBI, and NIA accounted for approximately 55% of all NIH nutrition related expenditures.<sup>1</sup>

NIH nutrition research funding increased by almost \$357 million (23%) between FY 2015 – FY 2019, but the increase was not a uniform trend across individual ICs. NIDDK and NHLBI increased nutrition funding (by 18% and 17% respectively), while NIA moved into the top three by increasing nutrition research funding by 91%. Selected other ICOs that had significant increases in nutrition funding include the OD (75%), NIMHD (75%), NIAID (68%), and NINDS (67%). In contrast, NCI reduced nutrition research funding by 10% over the same time period. Other ICs with a significant drop in nutrition research funding are NCCIH (-22%), largely due to the ending of a large program project and an overall reduction in the number of their nutrition-related research projects, and NIDA (-17%), largely related to a reduction in their nutrition-related intramural research.

The NIA increase in funding was spread across multiple mechanisms, including administrative supplements, research projects and programs grants. Specific areas with a large increase in funding included the Diabetes Prevention Program Outcomes Study (DPPOS) and multiple RFAs related to the impact diet on aging and the development of Alzheimer Disease. The NIMHD funding increase was largely driven by an investment in multiple specialized center cooperative agreements and the rise of nutrition-related research project grants on a variety of topics. The large increase in OD nutrition-related research funding was due to the launch of the Environmental influences on Child Health Outcomes (ECHO) program in FY 2016. NIAID increased nutrition-related funding primarily through their Consortium for Food Allergy Research, and the Asthma and Allergic Diseases Cooperative Research

<sup>&</sup>lt;sup>1</sup> For more information on FY 2015-2016 nutrition spending, see the NIH Nutrition Research Report 2015-2016 https://www.niddk.nih.gov/about-niddk/strategic-plans-reports/nih-nutrition-report

Centers as well as in the area of immunity in neonates and infants. NINDs nutrition-related funding was due to an increase in intramural funding, contributions to the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) and Helping to End Addiction Long-term (HEAL) Initiatives, and to the Rare Diseases Clinical Research Consortium.

The most recent nutrition research and training expenditures for NIH ICs are shown in Table 3 as total funding amounts and as percentages of their total obligation. Numbers of projects for each IC supporting nutrition research are also included. Although NIDDK, NHLBI, and NIA, collectively accounted for over half of the total NIH nutrition-related spending in FY 2019, in terms of the proportion of total IC budget dedicated to nutrition, the three leading NIH components were the NIDDK, the National Center for Complementary and Integrative Health (NCCIH), and NINR with 30 percent, 16 percent, and 10 percent, respectively.

# Table 1. Actual Obligations, NIH Biomedical Nutrition Research and Training in Current and Constant Dollars and as a Percentage of Total NIH Obligations FY 2015-2019 (in thousands of dollars)

Fiscal Year	Nutrition Research and Training, Current Dollars <sup>a</sup>	Nutrition Research and Training, Constant Dollars <sup>b</sup>	Total NIH Obligations <sup>c</sup>	Current Nutrition Dollars as a Percentage of Total NIH Obligations
2015	\$1,574,386	\$1,574,386	\$29,883,352	5.3%
2016	\$1,615,382	\$1,581,459	\$31,883,088	5.1%
2017	\$1,707,826	\$1,629,266	\$33,744,683	5.1%
2018	\$1,829,659	\$1,703,413	\$36,246,619	5.0%
2019	\$1,931,268	\$1,759,385	\$38,995,833	5.0%

a Expenditures. Source: NIH RePORT.

b Based on biomedical R&D price index, FY 2015 = 100 percent.

c Total excludes obligations for ORIP, SEPA and Buildings and Facilities.

Institute/ Center	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
FY Total	1,574,386	1,615,382	1,707,826	1,829,659	1,931,268
NIDDK	539,558	558,635	557,660	608,690	635,177
NHLBI	213,626	223,796	224,282	229,647	249,133
NCI	172,735	165,117	152,229	160,066	154,861
NICHD	117,777	100,685	100,023	109,473	113,195
NIA	90,131	85,857	104,546	149,592	172,485
ODa	68,480	65,711	71,442	87,425	119,775
NIGMS	55,394	62,587	71,703	80,937	77,204
NIEHS	51,715	53,955	73,249	62,425	66,422
NIAID	40,560	45,956	56,877	66,977	68,343
NIMH	31,677	33,607	34,594	35,949	38,136
NCCIH	30,510	33,242	25,953	29,819	23,808
NIAAA	26,627	32,892	30,086	29,313	24,844
NIDCD	19,837	19,862	21,224	23,492	21,955
NIMHD	19,578	24,233	24,184	30,042	34,254
NINDS	18,973	18,810	22,700	27,228	31,683
NIDCR	14,285	14,429	14,913	18,813	18,150
NEI	14,270	14,632	15,950	18,307	16,517
NIDA	13,101	16,129	14,145	12,346	10,860
NIAMS	12,110	12,468	12,894	16,873	19,651
NINR	10,993	14,239	14,297	17,258	16,046
NHGRI	5,964	8,476	8,926	6,796	9,899
NCATS	2,444	4,871	3,022	2,062	2,021
NIBIB	2,226	2,949	4,021	2,203	2,777
FIC	1,744	1,996	2,768	2,955	2,880
NLM	74	249	262	969	1,193

Table 2. Funding for Nutrition Research and Training by NIH ComponentFY 2015-2019 (ordered by FY 2015, largest to least, in thousands of dollars)

a Office of the Director (OD) includes Office of Disease Prevention, Office of Dietary Supplements, Office of Behavioral and Social Sciences Research, Office of Research on Women's Health, Office of Extramural Research, Office of Research Infrastructure Programs and NIH Roadmap/Common Fund.

Institute/	Number	Nutrition	TotalIC	Nutrition as
Center	Of Drojects	Research and	Obligations <sup>b</sup>	Percentage
	Projects	I failing.		Obligations
				Obligations
FIC	23	\$2,880	\$77,894	3.7%
NCATS	12	\$2,021	\$847,430	0.2%
NCCIH	93	\$23,808	\$145,933	16.3%
NCI	430	\$154,861	\$5,993,600	2.6%
NEI	40	\$16,517	\$793,767	2.1%
NHGRI	11	\$9,899	\$575,361	1.7%
NHLBI	568	\$249,133	\$3,482,237	7.2%
NIA	348	\$172,485	\$3,080,043	5.6%
NIAAA	68	\$24,844	\$525,282	4.7%
NIAID	172	\$68,343	\$5,567,138	1.2%
NIAMS	52	\$19,651	\$602,907	3.3%
NIBIB	8	\$2,777	\$388,079	0.7%
NICHD	324	\$113,195	\$1,508,603	7.5%
NIDA	29	\$10,860	\$1,621,334	0.7%
NIDCD	70	\$21,955	\$472,988	4.6%
NIDCR	39	\$18,150	\$460,613	3.9%
NIDDK	1599	\$635,177	\$2,099,265	30.3%
NIEHS	170	\$66,422	\$850,793	7.8%
NIGMS	259	\$77,204	\$2,821,806	2.7%
NIMH	88	\$38,136	\$1,869,653	2.0%
NIMHD	87	\$34,254	\$388,079	8.8%
NINDS	83	\$31,683	\$2,413,897	1.3%
NINR	43	\$16,046	\$163,165	9.8%
NLM	5	\$1,193	\$441,645	0.3%
OD	170	\$119,775	\$1,804,321	6.6%
TOTAL	4791	\$1,931,268	\$38,995,833	5.0%

# Table 3. NIH Nutrition Research Funding as a Percentage of Total IC Obligations,and Number of Projects by NIH Component, FY 2019 (dollars in thousands)

<sup>a</sup>Source: NIH RePORTER. <sup>b</sup>Source: NIH Office of Program Planning and Evaluation.

#### **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 which appear most frequently in projects categorized as Nutrition. Approximately half of the Nutrition projects funded in FYs 2017–2019 were also categorized as Prevention or Obesity and nearly half were categorized as Clinical Research.





\* Microbiome was a new spending category in FY 2018.

#### **Funding Mechanism**

Figure 2 shows the percent of FY 2017-2019 nutrition funding by research mechanisms. Extramural projects comprised 95% of the NIH nutrition research portfolio in FY 2019. Within the extramural category, Research Project Grants (RPGs) comprised the largest, and Training comprised the second largest, category of support.

The 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 make training awards to individuals selected by them for predoctoral and postdoctoral research training. The predoctoral and postdoctoral individual awards to provide research training to individuals to broaden their scientific background and extend their potential for research.



#### Figure 2. Nutrition Funding Percent by NIH Research Mechanism, FY 2017-2019

\*Other consists of multiple activities including conferences, cooperative agreements and SBIR-STTRs.

The NIH considers applications for the support of basic or clinical biomedical, behavioral, and bioengineering research. New extramural grant programs are made publicly available through Funding Opportunity Announcements (FOAs), also known as program announcements, requests for applications, notices of funding availability, solicitations, or other names depending on the agency and type of program.

Although nutrition research projects funded in FY 2017-2019 were received in response to over 700 different Funding Opportunity Announcements (FOAs), 40% came in under the Research Project Grant (Parent R01) FOA.<sup>2</sup>

<sup>&</sup>lt;sup>2</sup> All applications must be submitted in response to a Funding Opportunity Announcement (FOA). NIH and other HHS Agencies have developed omnibus Parent announcements for use by applicants who wish to submit what were formerly termed "unsolicited" applications. To learn more visit: http://grants.nih.gov/grants/guide/parent\_announcements.htm

Incoming applications adhering to NIH criteria are assigned to an NIH Institute or Center and to a scientific review group for evaluation of scientific and technical merit. FY 2017 - FY 2019 nutrition-related projects were reviewed by over 200 different scientific review groups across 25 ICOs.

# V. NIH NUTRITION RESEARCH NEWS

NIH-supported nutrition research led to important discoveries in 2017-2019. Many of these discoveries were announced in an NIH News Release or published in *NIH Research Matters*. The list below illustrates a sample of research highlights, and a more comprehensive list of NIH nutrition-related press releases and *Nutrition Research Matters* articles can be found in Table 4.

#### Highlights from NIH News Releases and NIH Research Matters

Cardiovascular Disease

 Moderately reducing caloric intake over a period of two years significantly improved cardiometabolic risk factors in young and middle-aged, non-obese adults, according to new findings from the Comprehensive Assessment of Long-term Effects of Reducing Intake of Energy (CALERIE) trial. Read more

#### Diabetes

• Taking a daily vitamin D supplement does not prevent type 2 diabetes in adults at high risk, according to results from a study funded by National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). Read more

#### **Dietary Patterns**

- In a small-scale, randomized controlled trial examining the effects of ultra-processed foods as defined by the NOVA classification system, people eating ultra-processed foods ate more calories and gained more weight than when they ate a minimally processed diet. The difference occurred even though meals provided to the volunteers in both the ultra-processed and minimally processed diets had the same number of calories and macronutrients. Read more
- Increasing time between meals made male mice healthier overall and live longer compared to mice who ate more frequently, according to a study conducted by scientists from the National Institute on Aging (NIA) at the National Institutes of Health, the University of Wisconsin-Madison, and the Pennington Biomedical Research Center, Baton Rouge, Louisiana. The researchers say their findings are encouraging for future studies on how these types of time-restricted eating patterns might help humans to maintain healthy weight and reduce some common age-related metabolic disorders. Read more

#### Food Allergy

Though food allergy affects more than 4.8 million children in the United States, no approved preventative treatments currently exist. To help alleviate this risk, a new study to evaluate an experimental treatment for food allergy launched August 1, 2019. The study is called Omalizumab as Monotherapy and as Adjunct Therapy to Multi-Allergen Oral Immunotherapy in Food Allergic Children and Adults or OUtMATCH. It will test the ability of biweekly or monthly injections of omalizumab—alone or together with multi-allergen oral immunotherapy (OIT)—to

increase a person's ability to tolerate foods to which they are allergic. The study is supported by the National Institute of Allergy and Infectious Diseases (NIAID), part of the National Institutes of Health; Genentech, a member of the Roche Group; and Novartis Pharmaceuticals Corporation. Read more

#### Infectious Diseases

 Research funded by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) and the National Institute of Allergy and Infectious Diseases (NIAID) provides a possible explanation for why iron can sometimes worsen malaria infection. Researchers found that extra iron interferes with ferroportin, a protein that prevents a toxic buildup of iron in red blood cells and helps protect these cells against malaria infection. They also found that a mutant form of ferroportin that occurs in African populations appears to protect against malaria. These basic findings may help researchers and healthcare officials develop strategies to prevent and treat malaria infections, which numbered nearly 216 million worldwide in 2016. <u>Read more</u>

#### Overweight or Obesity:

- Common recommendations from hospitals and infant formula manufacturers for introducing solid foods to infants could raise the risk of overfeeding or underfeeding, suggests a computer modeling study funded by the National Institutes of Health. The researchers recommend that medical and professional organizations, government agencies and industry consider developing consistent guidelines on how best to introduce infants to solid food, including appropriate portion sizes and food types based on whether the primary feeding type is breastmilk or formula. Read more
- Children born to women who had gestational diabetes and drank at least one artificially sweetened beverage per day during pregnancy were more likely to be overweight or obese at age 7, compared to children born to women who had gestational diabetes and drank water instead of artificially sweetened beverages, according to a study led by researchers at the National Institutes of Health. Read more

Table 4. Se	lected Nutrition.	Related NIH Nev	vs in 2017 - 20	019 in Reverse (	Chronological ()	rdor
1 abie 4. Se	aetteu Nutinion.	·Nelaleu IVIII IVEV	vs III 2017 - 20	019 III Kevelse	Chi onological O	'luel

DATE	TITLE
October 23, 2019	Pathogenic tau and cognitive impairment are precipitated by a high-salt diet
October 3, 2019	NIH-funded study suggests high lead levels during pregnancy linked to child obesity
September 13, 2019	Few people with peanut allergy tolerate peanut after stopping oral immunotherapy
August 1, 2019	Clinical trial to evaluate experimental treatment in people allergic to multiple foods
July 25, 2019	Guidelines for introducing solid foods to infants may lead to unhealthy weight
July 15, 2019	Extinct human species likely breast fed for up to a year after birth
July 12, 2019	Moderate calorie restriction in young and middle-aged adults significantly reduces heart and metabolic risk factors independent of weight loss
June 7, 2019	NIH-funded trial finds vitamin D does not prevent type 2 diabetes in people at high risk
May 16, 2019	NIH study finds heavily processed foods cause overeating and weight gain
April 30, 2019	Daily folic acid supplement may reduce risk of gestational diabetes
March 21, 2019	NIH study finds no evidence that calcium increases risk of AMD
March 8, 2019	Vitamin D may protect against pollution-associated asthma symptoms in obese children
February 11, 2019	Inexpensive supplement for women increases infant birth size
January 14, 2019	Gut microbes from healthy infants block milk allergy development in mice
December 10, 2018	Study links frequent red meat consumption to high levels of chemical associated with heart disease
November 9, 2018	Soy formula feeding during infancy associated with severe menstrual pain in adulthood
October 10, 2018	NIH study finds probiotic Bacillus eliminates Staphylococcus bacteria
October 9, 2018	NIH research projects to track activities of gut-derived metabolitese
October 3, 2018	Diet rich in fried and processed foods linked to increased hypertension in black Americans

September 11, 2018	High blood sugar during pregnancy ups risk of mother's type 2 diabetes, child's obesity
September 6, 2018	Longer daily fasting times improve health and longevity in mice,
June 14, 2018	NIH-supported researchers find link between allergen in red meat and heart disease
May 30, 2018	Insufficient vitamin D linked to miscarriage among women with prior pregnancy loss,
April 13, 2018	Omega-3s from fish oil supplements no better than placebo for dry eye
March 29, 2018	NIH study may help explain why iron can worsen malaria infection
January 24, 2018	Will supplements help your workout or diet routine?
January 18, 2018	Hold the salt: gut reaction may impair the brains of mice
January 11, 2018	Iodine deficiency may reduce pregnancy chances, NIH study suggests
January 3, 2018	DASH ranked Best Diet Overall for eighth year in a row by U.S. News and World Report
June 7, 2017	Pregnancy diet high in refined grains could increase child obesity risk by age 7, NIH study suggests
June 6, 2017	Drinking diet beverages during pregnancy linked to child obesity
May 2, 2017	NIH discovery in mice could lead to new class of medications to fight mid-life obesity
January 5, 2017	NIH-sponsored expert panel issues clinical guidelines to prevent peanut allergy

# VI. NIH-SPONSORED NUTRITION CONFERENCES, SCIENTIFIC MEETINGS, EDUCATIONAL OPPORTUNITIES, & VIDEOCASTS

NIH conferences, workshops, and symposia play a key role in the advancement of nutrition science. Such forums provide an opportunity to share information, identify research gaps, and to stimulate new areas of research. Table 5 lists relevant nutrition-related events that were sponsored or co-sponsored by NIH institutes and centers in 2017-2019. Each of the events selected for this table have a link to learn more about the meeting such as the agenda, video recording, or publications that resulted from the discussions that took place at the event.

Title	Event Type	Date	Additional Information
We are what we eat: nutrition, genes, cognition & deep learning in age-related macular degeneration	NIH Director's Wednesday Afternoon Lecture Series	December 11, 2019	NIH VideoCast Recording
Childhood Obesity Prevention Across Borders: The Promise of US-Latin American Research Collaboration	Scientific workshop	November 13-14, 2019	Workshop Overview
Sensory Nutrition and Disease Workshop	Scientific Workshop	November 12 - 13, 2019	Agenda
Lifestyle and Breast Cancer: Addition by Subtraction and the Value of Randomized Clinical Trials	NCI Stars in Nutrition and Cancer Lecture Series	October 16, 2019	NIH VideoCast Recording
Workshopon Metabolic Interactions between Folic Acid Excess and Vitamin B12 Deficiency	Scientific Workshop	July 31 - August 1, 2019	Agenda
The Physiology of the Weight Reduced State	Scientific Workshop	June 3 - 4, 2019	Agenda

#### Table 5: NIH-Sponsored Nutrition Conferences, Seminars & Webinars, In Reverse Chronological Order

Breaking the Obesity-	NCI Stars in Nutrition	March 12, 2019	NIH VideoCast
Cancer Link: New	and Cancer Lecture		Recording
Targets and Strategies	Series		
Waight Control and	NCI Store in Nutrition	October 2, 2019	NULIVideoCast
Eversion for Broast	NCI Stars in Nutrition	October 3, 2018	NIH VIDEOCAST
Exercise for Breast	Series		Recording
Cancer Prevention	Series		
NIH Workshop on	Scientific Workshop	September 26-27, 2018	Agenda
<b>Biomarkers of Dietary</b>			
Intake and Exposure:			Publication
Exploration with			
Omics Approaches			
Diet and Cancer	NCI Stars in Nutrition	March 13, 2018	NIH VideoCast
Prevention: Chewing	and Cancer Lecture		Recording
on the Human	Series		
Complexities			
	Colored Colored at the second	Dava ( 1 2017	D. Islandar
ine Vitamin D Paradox	Scientific Workshop	December 1, 2017	Publication
In Black Americans: A			
Approach to			
Approacting Clinical			
Dractice Research and			
Public Health			
Workshop on Human	Scientific Workshop	Nov. 16 - 17, 2017	Agenda
Milk Composition –			
Biological,			Publication
Environmental,			
Nutritional, and			
Methodological			
Considerations			
The Innate Immune	NCI Stars in Nutrition	November 13 2017	NIHVideoCast
Response to Natural	and Cancer Lecture		Recording
Products and to	Series		
Eustress			
Advancing Nutrition	Scientific Workshop	September 7-8, 2017	Publication
<b>Training and Research</b>			
for Medical Students,			
Residents, Fellows,			
Attending Physicians			
and other Clinicians			

Nutritional	Scientific Workshop	September 5-6, 2017	Agenda
Interventions to			
Promote Healthy			
Aging			
Workshop on Best	Scientific Workshop	June 13 - 14, 2017	Agenda
Practices for Studies of			
Diet and the Intestinal			Publication
Microbiome			
Emerging Role of	Scientific Workshop	May 25 - 26, 2017	Agenda
Branched-Chain Amino			
Acids in Human			
Diseases			
Aflatoxin: An Old	NCI Stars in Nutrition	March 21, 2017	NIH VideoCast
Carcinogen Teaches Us	and Cancer Lecture		Recording
New Tricks	Series		

# VII. NUTRITION PRACTICUMS

Several Institutes and Centers offer practicums with the goal of expanding specific research interests. Both the National Cancer Institute and the Office of Dietary Supplements 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 US Department of Agriculture (USDA) offer a one-week educational opportunity, the John Milner Nutrition and Cancer Prevention Research Practicum, in nutrition and cancer prevention research for individuals with a sustained commitment to nutrition and health promotion.

Offered since 2004, this one-week intense learning session provides specialized instruction in 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 (RDNs), students enrolled in an ACEND-accredited supervised practice program or combined with graduate studies, and non-government 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. Room, board, and transportation expenses are the responsibility of the participant. Full week commitment is required.

#### Mary Frances Picciano Dietary Supplement Research Practicum

The Mary Frances Picciano Dietary Supplement Research Practicum is offered by the Office of Dietary Supplements (ODS). The practicum is an annual two-and-a-half-day educational opportunity which provides fundamental knowledge of dietary supplements. This intensive practicum provides a thorough overview and grounding about 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 carry out this type of research.

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

# VIII. NUTRITION RELATED TRANS-NIH COMMITTEES

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

#### Nutrition Research Coordinating Committee (NRCC)

The NIH Nutrition Research Coordinating Committee (NRCC) was originally established in 1975 for the primary purpose of reviewing, discussing, and stimulating support for nutrition research and training within the NIH. Today, the NRCC is a vibrant group whose membership includes representatives and interested staff from NIH institutes, centers, offices, and other federal agencies. The NRCC is chaired by the director of the NIDDK Office of Nutrition Research. NRCC meetings occur monthly and typically include scientific seminars, nutrition research program and policy updates, information about research interests and collaborative project activities. In addition, a subcommittee of the Nutrition Research Coordinating Committee, the NIH Nutrition Education Subcommittee (NES), reviews federal nutrition education materials that contain dietary guidance for the general population.

#### Nutrition Research Task Force (NRTF)

The National Institutes of Health Nutrition Research Task Force (NRTF) was established in 2016 to coordinate and accelerate progress in nutrition research across the NIH and guide the development and implementation of the first NIH-wide strategic plan for nutrition research for the next 10 years. The NRTF draws from experts across multiple fields, as nutrition affects both a wide range of diseases — including diabetes, cancer, obesity, and heart disease — as well as overall health and normal development.

#### **Obesity Research Task Force (ORTF)**

The NIH Obesity Research Task Force was formed to provide the NIH research community with a means of exchanging information on a broad spectrum of NIH obesity-related research including molecular, genetic, behavioral, environmental, clinical, and epidemiologic studies. The Task Force is co-chaired by the Directors of the NIDDK, NHLBI, and NICHD. The members of the Task Force include representatives from these and many other NIH ICs. In 2011, the Task Force published an updated Strategic Plan for NIH Obesity Research to reflect recent obesity research activities and encourage innovative scientific research investigations to combat the obesity epidemic. The Plan reflects exciting opportunities and discoveries that have emerged since the first strategic plan was published in 2004.

#### Prevention Research Coordinating Committee (PRCC)

The PRCC is a trans-NIH committee that provides a forum for NIH Institutes and Centers, 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 (TMWG)

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. The TMWG meets monthly to provide a forum for coordinating NIH extramural research activities related to the human microbiome.

# IX. KEY FEDERAL COLLABORATIONS

Interagency collaboration enhances the field of nutrition. Highlighted below are some of the key collaborative efforts that took place during 2017-2019.

#### **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 USDA and HHS every five 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 2015-2020 Dietary Guidelines for Americans; but the 2020-2025 Dietary Guidelines for Americans development process is under way.

For the first time, the U.S. Departments of Agriculture (USDA) and Health and Human Services (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 – October 6, 2018. Twenty nationally recognized scientists were appointed to serve on the Committee in February 2019. The Committee's work will end with the release of its scientific report to the Secretaries of USDA and HHS. The two agencies will then work together to develop the next edition of the *2020-2025 Dietary Guidelines*. The Departments will consider the Committee's scientific report – along with input from other federal agencies and the public.

#### **Dietary Reference Intakes (DRI)**

Dietary Reference Intakes (DRIs) are nutrient reference values developed by the National Academies of Sciences, Engineering, and Medicine. The DRIs are intended to serve as a guide for nutritional intake and provide the scientific basis for the development of food guidelines in both 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.

The DRI Working Group has sponsored two NASEM consensus studies over the period of this report: *Guiding Principles for Developing Dietary Reference Intakes Based on Chronic Disease* (released August 2017), which was established after a deliberate nomination process to prioritize re-reviews of DRIs and three highest priority nutrients all potentially affected chronic disease endpoints, and *Dietary Reference Intakes for Sodium and Potassium* (released March 2019), which was mandated by Congressional budget language.

#### Dietary Supplement Ingredients Database (DSID)

The Dietary Supplements Ingredients Database (DSID) contains analytical data on dietary supplement product ingredients. The DSID was developed by the Nutrient Data Laboratory, US Department of Agriculture, in collaboration with the Office of Dietary Supplements at the National Institutes of Health (NIH) 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. The fourth release of the Dietary Supplements Ingredient Databases (DSID-4) released in August 2017—reports national estimates of ingredient content in adult, children's and nonprescription prenatal multivitamin/mineral (MVMs) and omega-3 fatty acid supplements.

#### Dietary Supplement Label Database (DSLD)

The Dietary Supplement Label Database (DSLD) is a joint effort between the NIH National Library of Medicine and Office of Dietary Supplements, with input from many federal stakeholders. The database contains the full label contents from a sample of dietary supplement products marketed in the U.S. with a Web-based user interface that provides ready access to label information.

#### Federal Data Consortium on Pregnancy and Birth to 24 Months

The Federal Data Consortium on Pregnancy and Birth to 24 Months (P/B-24, Data Consortium) 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 for Federal agencies to gather and vet input to inform projects and research plans and share information on data availability and usage. Over a dozen Federal agencies have funded projects coordinated by the Data Consortium 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, USAID, EPA, and DoD). The Data Consortium is co-led by representatives of ODPHP, CDC, NIH, and FDA of HHS and ARS and FNS of USDA.

The Data Consortium arose out of work by ODPHP/OASH in 2016 to coordinate "special studies" from CDC's National Health and Nutrition Examination Survey (NHANES) to fill crucial needs for data on P/B24 populations to support future Dietary Guidelines for Americans (DGA). However, the essentiality for these data goes beyond the needs of the DGA. Initiatives include The Human Milk Composition Initiative (Casavale et al. 2019) and new B-24 questionnaire content in the NHANES Diet and Behavior Questionnaire (Casavale and Woodwell, 2018).

#### Federal Working Group on Dietary Supplements (FWGoDS)

The Federal Working Group on Dietary Supplements (FWGoDS) is led by the NIH Office of Dietary Supplements and includes representatives from other NIH Institutes, Centers and Offices as well as other federal agencies. The FWGoDS provides an opportunity to strengthen collaborative efforts and to share information and discuss issues, initiatives, and research related to dietary supplements. The FWGoDS was established in part based on a Congressional law which specifies that ODS serve as an advisor to federal health agencies on issues related to dietary supplements and has met twice a year since 2005.

#### FDA-NIH Joint Agency on Nutrition (JAN) Working Group

The FDA-NIH Joint Agency on Nutrition (JAN) Working Group was formed in 2016 to facilitate highquality nutrition research to improve public health outcomes across the lifespan in order to: i) reduce the risk factors for and incidence of nutrition-related chronic disease; and ii) to inform nutrition-related regulatory decision-making and consumer outreach/education related to nutrition.

#### **Healthy People**

Healthy People is a national health promotion and disease prevention agenda that provides a framework to achieve ten-year goals and objectives to improve the nation's health. The Healthy People initiative, which began more than thirty 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. The National Institutes of Health 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 the 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 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 (ICHNR)

The Interagency Committee on Human Nutrition Research (ICHNR) aims to increase the overall effectiveness and productivity of federally supported or conducted human nutrition research. Created in 1983 and reassembled in 2013, the ICHNR is charged with improving the planning, coordination, and communication among federal agencies engaged in nutrition research and with facilitating the development and updating of plans for federal research programs to meet current and future domestic and international needs for nutrition. The ICHNR includes representatives from the departments of Agriculture (USDA), Health and Human Services (HHS), Defense (DoD) and Commerce; the Federal Trade Commission (FTC), the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), the Agency for International Development (USAID), the Environmental Protection

Agency (EPA), the Veterans Health Administration (VHA), and the White House Office of Science and Technology Policy (OSTP). In addition to its interagency coordination and communication roles, the 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 (NCCOR)

NCCOR is a public-private partnership undertaken by the Centers for Disease Control and Prevention (CDC), the NIH (NCI, NICHD, NIDDK, NHLBI, and OBSSR), the Robert Wood Johnson Foundation (RWJF), and the USDA. The initiative was formally 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 2017 NCCOR Annual Report and the 2018 NCCOR Annual Report are both 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, a Measures Registry User Guide, Measures Registry Learning Modules, a Catalogue of Surveillance Systems, a Registry of Studies, and a Youth Compendium of Physical Activity.

#### National Food and Nutrient Analysis Program (NFNAP)

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 the NCI and the ODS, along with other NIH Offices and Institutes 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, the development of unique statistically based sampling plans, and the application of validated analytical chemistry. The primary outcome of the Program is to develop comprehensive nutrient composition databases having 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 here. The NFNAP initiative has also 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 AND CENTER RESEARCH DIRECTIONS

The 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 each IC's specific research directions and priority nutrition areas are below.

Clinical Center (CC) Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) 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) 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 Disparities (NIMHD) National Institute of Neurological Disorders and Stroke (NINDS) National Institute of Nursing Research (NINR) Office of the Director (ODS)

# Clinical Center (CC) http://clinicalcenter.nih.gov/

#### OVERVIEW

The Clinical Center at the National Institutes of Health (NIH) in Bethesda, Maryland, is part of the 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, there are about 1,600 clinical research studies in progress at the NIH Clinical Center. The clinical trials at the NIH Clinical Center are predominantly Phase I and Phase II, often first-in-human 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 transference 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 the NIH.

The Mark O. Hatfield Clinical Research Center was opened in 2005. The facility houses inpatient units, day hospitals, and research labs 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 assure valid and reliable data and assist with data collection, analysis, interpretation, and manuscript preparation. Dietitians 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 utilizing 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 utilized 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.

#### CONTACT

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# *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD)

http://www.nichd.nih.gov/

Nutrition Research Spending (FY 2019):	\$113,194,633
Nutrition as Percentage of Total IC Obligations (FY 2019):	7.5%

#### OVERVIEW

Consistent with the NICHD mission, the nutrition research program is focused on the continuum of human development, from conception 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 of conditions and stresses that can impact health.

Coordinated through the Pediatric Growth and Nutrition Branch, NICHD's extramural nutrition portfolio is multidisciplinary in nature, involving research to understand the genetic, biochemical, developmental (physical and neurological), behavioral, and cultural role of diet and nutrition in health promotion, disease prevention, and treatment. The historical focus of the NICHD nutrition extramural portfolio has been on several core areas:

- Nutrient requirements and best feeding practices for newborn infants including full term, premature, and low birth weight infants
- Lactation
  - o Mammary gland development and physiology
  - Ontogeny of breast milk
  - Human milk composition
  - Factors affecting prevalence of breastfeeding
  - $\circ$   $\;$  Lactation performance and initiation and duration of breastfeeding
  - o Social/behavioral factors influencing infant feeding choices
- Intake regulation
  - Social/cultural/behavioral aspects
  - Sensory response (i.e., development of hedonic response to food/dietary constituents)
- Growth and development
  - Physical (e.g., bone health, body composition)

- Neurological including effects on cognitive/behavioral outcomes
- Evaluation of the role of nutrition in the ontogeny, prevention, and care of disease both acute and long-term
  - o Prematurity
  - o Infection, HIV, tuberculosis, malaria, diarrheal diseases
  - Non-communicable diseases (NCDs) including obesity, diabetes, bone disease, cardiovascular disease risk, and cancer

Within this broad agenda, NICHD supports programs that address related issues such as:

- Impact of nutrition on reproduction
- Impact of maternal nutrition on pregnancy outcomes and lactation
- Nutritional therapy of inborn errors of metabolism
- Assessment of nutritional status including the discovery, development, and deployment of sensitive and specific biomarkers of nutrient status
- Understanding nutrition as a biological variable including:
  - Role of nutrients within biological systems (e.g., neurological, immunological, or organs such as the placenta)
  - Intersection of nutrition (including infant feeding practices) and the microbiome particularly as pertains to development of gut immunology, health promotion, and disease prevention of infants
  - Role of nutrition as both a predictor and an outcome of infectious diseases (e.g., HIV, malaria, TB, diarrheal disease) and non-communicable diseases (e.g., diabetes, cardiovascular disease, cancer) and their treatment

NICHD's interest in the above areas continues to expand. In response to needs identified during the course of the process of including pregnancy and the first two years of life in future iterations of the US Dietary Guidelines for Americans (DGA), NICHD has refocused its efforts on: (1) an expanded appreciation of not only the composition of human milk but understanding how/why human milk acts as a biological system including an expanded appreciation of both maternal and infant inputs; (2) how the understanding of that system can be better translated into best practices for feeding infants (term and preterm); and (3) best practices for feeding infants >6 months, including the nutrient requirements for healthy growth and development and the modes for delivery of those nutrients to infants beyond the period of exclusive breastfeeding (>6 months of age). Interest centers on metabolic processes in neonatal adaptation and on the role played by essential nutrients and other components of human milk. For example, NICHD has supported seminal work elucidating the effects of specific bioactive components of human milk (e.g., oligosaccharides and lactoferrin) on the development of the gut microbiome, immune function, and nutrient delivery.

NICHD continues to encourage research on cultural and behavioral determinants of dietary patterns including studies of factors affecting the development of eating habits, taste, and olfaction; food avoidances; and behavior modification of dietary intake. An additional area of emphasis is understanding social/behavioral/cultural factors that influence maternal/caregiver infant feeding choices, as well as biological influences on successful implementation and sustainability of breastfeeding.

NICHD plays a leadership role in efforts to understand the role of the fetal environment in subsequent health outcomes including development of adult diseases. In a similar vein, the portfolio is actively growing in studies of the origins of childhood obesity and other components of metabolic syndrome later in life. A focus of these efforts has been on those factors that contribute to documented health disparities in the US.

In the area of international nutrition research, NICHD has played a leadership role within the NIH community through the development of the trans-NIH Subcommittee on International Nutrition Research, a subcommittee of the NIH Office of Nutrition Research's Nutrition Research Coordinating Committee (formerly, Nutrition Coordinating Committee). The current NICHD international nutrition research portfolio is coalesced around areas of traditional interest (e.g., the role and impact of specific micronutrients [e.g., vitamin A and iron] in maternal and child health), as well as emerging programs in the intersection of food systems, nutrition, and health in a changing global environment. Among the current priorities are the safety and effectiveness of common nutritional interventions in the context of prevention, care, and treatment of infectious diseases (e.g., HIV, malaria, and TB) and noncommunicable diseases in resource constrained settings. A current area of particular interest is NICHD leadership in a USAID Anemia Task Force to better understand a) the biology, b) assessment and c) approaches to translation of that understanding to improved surveillance and interventions to address this high priority global target. Through partnerships with other funding agencies (e.g., the Bill and Melinda Gates Foundation) and the global health community (as technical consultant to the World Health Organization) and as a founding participant in the US Government's Global Nutrition Coordination Plan (involving all USG agencies involved in food/nutrition and global health), NICHD has played an important role in addressing a range of issues affecting global health programs and policies.

The ability to identify, develop, and implement biomarkers to assess nutrient status continues to be a high priority for NICHD. For example, the "Biomarkers of Nutrition for Development: BOND" program continues to inform the domestic and global community through efforts such as the Micronutrient Forum, and the aforementioned USAID Anemia Task Force which includes a role as a technical resource in efforts to better determine global prevalence of micronutrient malnutrition.

The linkages and predictors of dietary pattern and health are also conducted in NICHD's intramural divisions. For example, the SPROUTS study (SPROUTS: Development of Eating Behaviors in Young Children), supported by NICHD's Division of Intramural Population Research, is a sequel to the Pregnancy Eating Attributes Study (PEAS follows a cohort of children 3 to 5 years of age to investigate relationships of child eating behaviors and neuro-behavioral responses to food (e.g., eating in the absence of hunger, attentional bias to food cues, food reinforcement value, self-regulation) with maternal dietary intake
and food reward-related characteristics, infant feeding practices and eating behaviors, and early life exposure to discretionary foods. Recruitment for Sprouts began in March 2019, with data collection to be completed by spring, 2024.

#### CURRENTLY FUNDED RESEARCH PROJECTS

The following examples of current nutrition research supported by NICHD show the range and depth of the NICHD nutrition portfolio.

- As part of a long-term commitment that began in 1969, NICHD is currently supporting a followup multi-generational study leveraging data from a unique cohort of children in Guatemala who received supplemental nutrition in early childhood, to assess the relationship between early nutrition and cardiometabolic risk (R01HD075784).
- A study focused on children during the transition to adolescence (ages 8-12), testing the hypothesis that household food insecurity increases children's psychological stress, which shapes their eating behaviors and food choice and predicts subsequent weight gain (K99HD084758).
- A study of the effect of infant diet on neurodevelopment using a novel biomarker. Building upon a previously validated element (barium) that is a specific marker of infant diet transitions, the goal is to identify elemental signatures in children's teeth that distinguishes breast milk from infant formula intake, as well as the duration of exclusive breastfeeding. Using a subset of 100 children from the longitudinal birth cohort *Early Life exposures in Mexido and NeuroToxicology* (ELEMENT) study, the investigators are examining the associations of exclusive breastfeeding duration, and breast milk and formula dose, with neurodevelopment outcomes (R00HD087523).
- A multi-center RCT of refeeding in anorexia nervosa (AN) is comparing the efficacy, safety and cost-effectiveness of two refeeding protocols in achieving short- and long-term recovery in adolescents with AN. The investigators hypothesize that Higher Calorie Refeeding (HCR) will result in superior outcomes than the current standard of care known as Lower Calorie Refeeding (LCR), which is linked to poor outcomes (R01HD082166).
- To better understand the associations between human milk oligosaccharides (HMOs) and infant growth, body composition and obesity, NICHD is supporting a study pairing existing datasets and bio-banked milk samples from the Finnish mother-infant STEPS cohort with new state-of-the-art high-throughput technology for HMO analysis. The investigators hypothesize that (1) HMO composition in mother's milk is associated with growth, body composition, and obesity risk, and (2) maternal factors influence HMO composition. Discoveries from this exploratory project will inform new approaches for disease prevention (R21HD088953).
- A study on mammary and milk microbiomes and metabolomes seeks to understand early variation and impacts on risk for mammary inflammation and mastitis. The project is (1) comparing and contrasting the milk microbiome, its functionality, immune parameters, and inflammatory markers in healthy and mastitic women and cows, and (2) identifying milk microbial profiles and their functionality related to risk for mammary inflammation. The results

of this research will lead to better understanding of how the microbiology of the lactating mammary gland is related to mammary inflammation and will lay the groundwork for future studies of treatment and prevention (R01HD092297-03).

- A study of newborn iron deficiency (ID) focuses on the cellular mechanisms of how developmental ID causes long-term neuronal structural deficits and whether these can be prevented or treated. The project will elucidate how specific deficits in neuronal energy metabolism induced by early-life ID lead to long-term abnormalities in mitochondrial metabolism and neurological deficits and will test therapies to prevent them (R01HD094809).
- A study of infant communication of nutritional needs uses a unique biological model—the social tadpole—to uncover how infants evaluate their nutritional state, and communicate they need food. If/how nutritional quality influences the development of neurons that regulate feeding and communication will be examined using in vivo brain imaging. The study has implications for preventative strategies and treatments for childhood obesity and autism spectrum disorders (DP2HD102042).

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### **Fogarty International Center (FIC)** http://www.fic.nih.gov/Pages/Default.aspx

Nutrition Research Spending (FY 2019):	\$2,879,908
Nutrition as Percentage of Total IC Obligations (FY 2019):	3.7%

#### OVERVIEW

The Fogarty International Center (FIC) is dedicated to advancing the mission of the NIH by supporting and facilitating global health research conducted by U.S. and international investigators, building partnerships between health research institutions in the U.S. 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 (LMIC). FIC staff engage with scientists around the world to address critical global health research problems such as emerging infectious diseases, and 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 projects funded by FIC aim to do the following:

- Design and implement an effective and culturally appropriate breastfeeding training program for peer counselors, which will include a multimedia content, to aid counselors in educating and supporting mothers to increase their commitment to exclusively breastfeed their infants to six months and adopt other recommended breastfeeding practices in India<sup>3</sup>
- Training PhD-level HIV research leaders from the University of Zambia in nutritionally- and metabolically related complications and comorbidities of HIV, including innovative multidisciplinary mentored dissertation research focused on the key metabolic and nutritional challenges in long-term HIV care<sup>4</sup>
- Identify risk factors for sub-optimal breastfeeding and opportunities for breastfeeding promotion among working mothers and determine the impact of adopting breast feedingsupportive policies and practices among mothers involved in unskilled manual labor on women's productivity in Kenya<sup>5</sup>
- Develop and test a smartphone application designed to 1) support self-management and treatment of gestational diabetes mellitus among patients in a suburban hospital setting in

<sup>&</sup>lt;sup>3</sup> R21TW010609

<sup>&</sup>lt;sup>4</sup> D43TW009744

<sup>&</sup>lt;sup>5</sup> K01TW010827

Nepal taking a user-centered design approach, and 2) provide easily digestible clinician-level information to aid clinical decision-making and counseling<sup>6</sup>

- Test the effect of repeated exposure to warning labels on sugary drinks purchased by adolescents in Guatemala and catalyze non-communicable disease (NCD) research capacity building in the country by 1) working with faculty, trainees, and fellows on the proposed empirical research; and 2) offering a short course on NCD research for Cancer Institute in Guatemala trainees and researchers<sup>7</sup>
- Understand use of Moringa oleifera leaves to provide chemically stable, low-cost and sustainable diet-based therapeutic agents to prevent and treat chronic inflammation and related metabolic and cardiovascular conditions in Kenya<sup>8</sup>
- Assess the pathways linking the water and food exposures to the dual burden of under- and over-nutrition to identify the effects of changing environments on human health in Galapagos, Ecuador<sup>9</sup>
- In the Pakistan Water Sanitation, Health and Hygiene Intervention study, extensive surveillance of more than 1800 children under age 5 was done from 1989-1996 and subsequently in a young adult follow-up 15-20 years later. This research project aims to determine long term health impact of early childhood diarrhea, pneumonia, and nutritional status on later growth and educational development.
- The MAL-ED (Malnutrition and Enteric Diseases) project was an international collaboration investigating the effects enteric pathogens, nutrition and socio-economic status (SES) 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 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 five years of age. Running from 2008-2019, the multi-site project was supported by Bill & Melinda Gates Foundation. (See list of nutrition-related publications).

#### MAL-ED Nutrition-related Publications 2017-2019:

- McCormick BJJ, et al. Intestinal permeability and inflammation mediate the association between nutrient density of complementary foods and biochemical measures of micronutrient status in young children: results from the MAL-ED study. Am J Clin Nutr. 2019 Oct 1;110(4):1015-1025.
- Nahar B, et al. Early childhood development and stunting: Findings from the MAL-ED birth cohort study in Bangladesh. Matern Child Nutr. 2019 Jun 25:e12864.

<sup>&</sup>lt;sup>6</sup> R21TW011377

<sup>&</sup>lt;sup>7</sup> R21TW010837

<sup>&</sup>lt;sup>8</sup> K01TW009987

<sup>&</sup>lt;sup>9</sup> R21TW010832

- McCormick BJJ, et al. Early Life Child Micronutrient Status, Maternal Reasoning, and a Nurturing Household Environment have Persistent Influences on Child Cognitive Development at Age 5 years: Results from MAL-ED. J Nutr. 2019 Aug 1;149(8):1460-1469.
- Richard SA, et al. Enteric dysfunction and other factors associated with attained size at 5 years: MAL-ED birth cohort study findings. Am J Clin Nutr. 2019 May 25.
- MAL-ED Network Investigators. Early childhood cognitive development is affected by interactions among illness, diet, enteropathogens and the home environment. findings from the MAL-ED birth cohort study. BMJ Glob Health. 2018 Jul 23;3(4).e000752.
- Richard SA, et al. Relationships among Common Illness Symptoms and the Protective Effect of Breastfeeding in Early Childhood in MAL-ED. An Eight-Country Cohort Study. Am J Trop Med Hyg. 2018 Mar;98(3).904-912.
- MAL-ED Network Investigators. Relationship between growth and illness, enteropathogens and dietary intakes in the first 2 years of life. findings from the MAL-ED birth cohort study. BMJ Glob Health. 2017 Dec 28;2(4).e000370.
- MAL-ED Network Investigators. Childhood stunting in relation to the pre- and postnatal environment during the first 2 years of life. The MAL-ED longitudinal birth cohort study. PLoS Med. 2017 Oct 25;14(10).e1002408.

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### National Cancer Institute (NCI) http://www.cancer.gov/

Nutrition Research Spending (FY 2019):	\$154,860,699
Nutrition as Percentage of Total IC Obligations (FY 2019):	2.6%

#### OVERVIEW

Cancer is the second leading cause of death in the United States. In 2019, the number of new cancer cases was estimated to be 1,762,450 and about 606,880 people died from the disease.<sup>10</sup> Since the 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/or 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 includes 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. 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 as Dietary Analysis Tools, Food Composition Databases, Data Collection Tools and in Dietary Assessment Methods.

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 (animal models and cell cultures), clinical biochemical/physiologic assessments of nutrient metabolism and absorption patterns, and in diet and lifestyle behaviors. In addition, NCI provides summaries of ongoing research related to nutrition and

<sup>&</sup>lt;sup>10</sup> Cancer Facts & Figures 2019, https://www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2019.html

cancer through Web sites and other programs within the Office of Communications and Public Liaison. Such websites include:

- Epidemiology and Genomics Research Program:
  - Selected Projects: https://epi.grants.cancer.gov/dietary-assessment/#selected
  - Dietary Assessment Research Resources: https://epi.grants.cancer.gov/dietaryassessment/resources.html
- Health Behaviors Research Branch: https://cancercontrol.cancer.gov/brp/hbrb/index.html
- CLASS [The Classification of Laws Associated with School Students (CLASS) protects the wellbeing of students by monitoring, classifying, and evaluating physical education and nutrition policies across the United States]: https://class.cancer.gov/
- Metabolic Epidemiology Branch: https://dceg.cancer.gov/about/organization/programsebp/meb
- Nutritional Science Research Group (NSRG): https://prevention.cancer.gov/researchgroups/nutritional-science

#### **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 and/or encouraged, the following are of particular importance:

#### **Dietary Assessment Methods**

- Innovative and novel technologies for assessing diet, weight control, and physical activity behaviors, such as electronic handheld monitoring devices and internet surveys 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 and physical activity 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, 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 non-essential 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
- Trans-disciplinary research to discover and characterize mechanisms by which diet, weight, and physical activity interacts 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, 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
- Investigating the mechanisms for which diet and nutritional interventions 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, California 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), 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 nutrition and physical activity through the NCI Health Information National Trends Survey (HINTS)
- Trans-NIH 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, weight control, and physical activity to assist in the understanding of factors influencing decisions at the population level and within clinical practice

#### Development of Evidence-Based Interventions

- Trans-disciplinary 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 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 asset 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 psychosocial and built environment. Examples include 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 (NCCIH)

https://nccih.nih.gov/

Nutrition Research Spending (FY 2019):	\$23,808,248
Nutrition as Percentage of Total IC Obligations (FY 2019):	16.3%

#### 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 mechanisms, usefulness, and safety of complementary and integrative approaches and their roles in improving health and health care. There are many definitions of complementary and integrative health. NCCIH simply defines these as a group of diverse medical and health care interventions, practices, products, or disciplines that may have originated outside of conventional medicine, such as natural products and mind and body approaches, and are increasingly being integrated into mainstream health care. NCCIH includes in our definition of natural products the use of dietary supplements and probiotics.

#### NATURAL PRODUCTS RESEARCH

Establishing priorities across the entire field of complementary and integrative health research is enormously challenging. NCCIH-supported research clearly intersects with nutrition, for example NCCIH's robust natural products research portfolio includes dietary supplements, herbal and botanical products, probiotics, and food-based phytochemicals. NCCIH also supports research on certain types of diets (e.g. ketogenic) that are not considered mainstream. 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 quality and integrity of products used in NCCIH-supported research. Read more at: http://nccih.nih.gov/research/policies/naturalproduct.htm.

#### **RESEARCH DIRECTIONS**

NCCIH research priorities are guided by our Strategic Plan (https://nccih.nih.gov/about/plans). Our primary research objectives are:

- Advance Fundamental Science and Methods Development
- Improve Care for Hard-to-Manage Symptoms
- Foster Health Promotion and Disease Prevention

Historically, NCCIH has supported most of our 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 at

https://nccih.nih.gov/grants/funding. 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.

Going forward, a portion of NCCIH's natural product research funding will be targeted toward more selected areas of basic, mechanistic, translational, and clinical research to expedite the development of these promising leads. NCCIH is eager to partner with other NIH Institutes, Centers, and Offices on areas of shared interest. Examples of existing collaborations include participation in trans-NIH Microbiome initiatives and collaboration with the NIH Office of Dietary Supplements on the Botanical Dietary Supplements Research Centers Program.

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### National Eye Institute (NEI)

http://www.nei.nih.gov/

Nutrition Research Spending (FY 2019):	\$16,517,173
Nutrition as Percentage of Total IC Obligations (FY 2019):	2.1%

#### OVERVIEW

NEI's mission is to reduce the prevalence of blindness, visual impairment, and eye disease in the United States and throughout the world. According to the World Health Organization, three quarters of the 45 million cases of blindness worldwide are considered curable or preventable. Xerophthalmia, a blinding disease caused by vitamin A deficiency, is the leading cause of nutrition-related blindness and visual impairment among the world's children. It accounts for 70 percent of the estimated 1.5 million blind children in the world. Mild vitamin A deficiency, with consequences for child health and survival, affects another 20 to 40 million children worldwide.

Age-related cataract and macular degeneration are the major causes of visual impairment and blindness in the aging U.S. population. NEI supports research on the role of nutrition and of micronutrients, such as vitamins and trace minerals with antioxidant capabilities, in the development and worsening of these two eye disorders. NEI-supported scientists also are evaluating the effect of nutritional factors on other visual disorders, such as retinopathy of prematurity, glaucoma, retinitis pigmentosa, and diabetic retinopathy.

#### **RESEARCH DIRECTIONS**

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

- The major epidemiological and randomized placebo-controlled clinical trial "Age-Related Eye Disease Study" (AREDS) showed that high levels of antioxidants (vitamin C, vitamin E, and beta carotene) and zinc reduced the risk of progression to advanced age-related macular degeneration (AMD) by 25 percent for those at high risk.
- A follow up study, AREDS2 tested a new formulation, adding omega-3 fatty acids as well as substituting antioxidants lutein and zeaxanthin for beta-carotene, which has been implicated as a risk factor for lung cancer in smokers and former smokers. While the omega-3 fatty acids had no effect on the formulation, the combination of lutein and zeaxanthin was a successful substitution, and this new formulation provides a safe and effective treatment for people at risk of advanced AMD. NEI is following a subset of patients annually for up to 18 years.
- As ancillary studies to the VITamin D and OmegaA-3 TriaL (VITAL) randomized trial, investigators
  will examine effects and synergism of DHA and EPA supplements from fish oil and vitamin D in
  reducing incidence or progression of AMD and dry eye disease (DED). The Dry Eye Evaluation
  and Management (DREAM) Study is a sequential set of two double-masked randomized trials to
  study the efficacy of long-term omega-3 supplementation on DED.

- Animal models for AMD are often limited because only primate eyes have a macula. To follow
  up epidemiological studies of nutritional factors like carotenoids on AMD risk, NEI longitudinal
  research is taking advantage of three aging primate (macaque) populations that have had
  controlled diets from previous research: a) monkeys with lifelong healthy diets b) monkeys with
  otherwise healthy diets but devoid of carotenoids lutein and zeaxanthin; c) aging monkeys with
  diets high in fat and sugar, mimicking typical American diet.
- Premature, low birth weight infants are at high risk for retinopathy of prematurity (ROP), a leading cause of ocular blindness in children. In animal studies, long-chain fatty acids suppress ROP. An NEI study suggested that adding dietary fatty acids increase levels of adiponectin, communicating signals to the retina to regulate the creation of disease-causing blood vessels (neovascularization) in the eye. Adiponectin deficiency blocked the dietary fatty acid suppression of neovascularization.
- Epidemiology studies are elucidating the interacting roles of environmental and genetic risk factors for complex eye diseases by examining diet and lifestyles in different populations. Using blood tests or nutritional surveys, the importance of fish oils, carotenoids, and vitamins for eye disease are being studied.
- Carotenoid levels, measured easily, safely and at low cost, are known to vary by individual, influenced by factors such as dietary sources, total nutrient intake, vitamin supplementation, genetics, and metabolism. NEI research is conducting long-term follow up on a cohort of participants from a clinical trial on carotenoids in eye disease to understand better the factors characterizing individual variation in carotenoids within population subgroups and to determine whether clinically significant relationships exist between carotenoid levels and incidence or progression of signs of age-related eye disease, specifically age-related macular degeneration. Pending a clinically meaningful relationship between carotenoids and eye disease, this research may inform future strategies to arrive at optimal dietary or vitamin supplementation over the life span.
- Macular pigment (MP) is comprised of the dietary carotenoids lutein, zeaxanthin and mesozeaxanthin and declines with age. NEI scientists are testing the hypothesis that MP is a modifiable risk marker for AMD, and that preserving MP might help reduce risk for developing eye diseases and vision loss. Another study showed type 2 diabetes was associated with lower density of MP.
- Basic research on the metabolism of nutritional compounds, such as carotenoids using animal models, complements epidemiological studies of the eye. Animal models also are useful for testing nutritional/pharmacological therapies to prevent proliferative diabetic retinopathy (PDR), for example. Diets rich in omega-3 fatty acids counter the effects of diabetic retinopathy; scientists are testing the ability of these fatty acids along with COX-2 inhibitors, such as aspirin, to target inflammatory and angiogenic factors in PDR.
- NEI grantees are investigating the role of oxidative stress in age- and diabetes-related eye diseases, such as AMD, cataract formation, and glaucoma. Scientists are testing if dietary interventions can modify these biochemical markers of oxidative stress in AMD patients with

different backgrounds. Eicosapentaenoic acid (EPA) added to cultured retina neurons blocked cell death in response to oxidative stress, whereas related fatty acids had no effect. Other teams are examining the mechanisms by which caloric restriction protects retinal cell death in glaucoma and whether these mechanisms can be reversed through dietary supplements such as resveratrol, a natural compound found in red wine.

- 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. Alterations of ocular tissue integrity and metabolism brought about by chronic deficiency of vitamin A also are being studied. These investigations include studying the role of vitamin A in maintaining the immune competence of the eye and the ability of ocular tissues to respond to infections and trauma.
- During eye development, precisely controlled programmed cell death is needed to separate the lens from the precursor to the cornea. Vitamin A deficiency can disrupt this process causing congenital blindness known as Peters' anomaly. NEI research is investigating the signaling mechanisms of vitamin A metabolite retinoic acid and its role in programmed cell death in the early stage of ocular lens and anterior eye development.
- Vitamin D, predominantly produced in the skin in response to UV sunlight, may also be produced in the cornea. It may also have a role in intraocular pressure control and AMD. NEI research is focusing on Vitamin D metabolism in the cornea, in tear fluid and its role in ocular wound healing. Vitamin D deficiency may affect over 50 percent of the United States population.
- Corneal scarring can develop as result of physical trauma, chemical burns, or infection, is a leading cause of blindness worldwide. Caloric restriction has been shown to extend lifespan and increase resistance to acute stress, and is correlated with improved outcomes following liver surgery. An exploratory study is testing if pre-surgical dietary restriction can modulate corneal wound healing.
- Cystoid macular edema (CME), swelling of the retina, is a complication occurring in 25 percent of patients with retinitis pigmentosa, but may be reduced by iodine supplements. Researchers are studying the role of dietary iodine, as well as linolenic acid, in reducing the risk of CME.
- As an ancillary study to a placebo-controlled trial examining multivitamin and cocoa supplements in cardiovascular disease and cancer prevention (COSMOS), NEI is looking for effects in AMD and cataract.

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## National Heart, Lung, and Blood Institute (NHLBI) http://www.nhlbi.nih.gov/

Nutrition Research Spending (FY 2019):	\$249,133,384
Nutrition as Percentage of Total IC Obligations (FY 2019):	7.2%

#### OVERVIEW

Heart diseases remain the leading causes of death in the U.S., although the past decade has seen a remarkable decline in the disease prevalence in the overall population.<sup>1</sup> Chronic lower respiratory diseases rank fourth among the 10 leading causes of death, which account for 74% of all deaths in the US.<sup>1</sup> Racial/ethnic minority groups are more adversely affected than other groups. The prevalence of heart disease and stroke appear to be increasing among minority groups.<sup>2</sup> These diseases, which are within the purview of the NHLBI impose a heavy burden on the health and economy of the American people. Taken together, cardiovascular, lower respiratory, and cerebrovascular diseases accounted for 3 of the 5 leading causes of death in adults and 4 of the 10 leading causes of death in infants. These diseases also account for a third of all deaths in 2017.<sup>3</sup> The number of deaths attributable to cardiovascular disease (CVD) declined from 1999 until 2011, but increased each year from 2012 to 2017 for a total increase of nearly 8% (from 599,711 deaths in 2012 to 647,457 deaths in 2017).<sup>3,4,5</sup> The estimated economic cost of heart, lung, and blood diseases in the US was \$487.6 billion in 2013-2014.<sup>6</sup> The total economic loss due to sleep deficiency and related disorders in the US is estimated to be \$411 billion.<sup>7</sup>

Nutrition is a major contributor to population health and globally, poor nutrition accounts for 45% of all deaths. An important overall goal of the NHLBI nutrition research program is to promote cardiovascular health, prevent and treat cardiovascular diseases, 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 well-characterized risk factors such as high blood cholesterol levels, high blood pressure, obesity, and poor levels of cardiovascular and physical fitness. Consequently, clinical trials are also needed to develop effective solutions to promote cardiovascular and respiratory health. Emerging cardiovascular risk factors such as elevated 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 life-long 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 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 triggering changes in appetite regulation, calorie intake, adipose function, and energy expenditure.<sup>8,9</sup> The molecular circadian clock serves as a cellular energy sensor that responds to dietary nutrients, re-dox state and ATP availability, in turn driving 10-20% of gene expression in metabolically active tissues.<sup>8,9</sup> The circadian clock is well positioned to integrate nutrient signaling, cellular metabolism and systemic physiology contributing to obesity and obesity-related cardiovascular disease.

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, 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:

#### **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 cardiovascular disease mechanisms.
- Investigate the interaction of nutrients or dietary factors with pharmacologic agents to reduce cardiovascular disease risk.
- Investigate the interaction of nutrients or dietary factors with the gut microbiome as a mediator of cardiovascular risk associated inflammation.
- Develop animal models to study hypertension, dyslipidemias, obesity, and other nutritionrelated cardiovascular risk factors and target organ damage.
- Investigate the interactions between genetic factors and diet as they influence cardiovascular disease risk.
- Develop new biomarkers of nutrient metabolism for use in studies of the causation, prevention, or treatment of cardiovascular diseases.

- Investigate racial, ethnic, and gender differences in nutrition-related cardiovascular disease risk, nutrient metabolism, dietary habits, and responsiveness to dietary intervention.
- Identify behavioral, social, and environmental determinants of nutrient intake, dietary patterns, and health that relate to or affect cardiovascular risk.
- Elucidate the role of body weight and fat distribution as related to the development of cardiovascular disease 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.

#### 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 cardiovascular disease.
- 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, etc.), genetics, and the environment (e.g., home, community, and 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.

#### Assessment

- Monitor secular trends in dietary constituents related to cardiovascular disease and its risk factors.
- Continue surveillance of public knowledge and physician practices that pertain to diet, obesity, and cardiovascular disease.

- 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.

#### Lung Diseases and Sleep Disorders

- 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 like BPD/Muscular Dystrophy/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.
- 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.
- 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.

- Evaluate the relationship between diet and genetic factors in determining an individual's susceptibility to diseases of the lung.
- Examine undernutrition as a risk for tuberculosis and other lung infections.
- Evaluate the effect of maternal diet during pregnancy on the development of allergies and asthma in the offspring.

#### **Blood Diseases**

- Investigate the role of food insecurity and food deserts in obesity and overweight in hemoglobinopathy patients.
- Identify 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.

#### **Cross Cutting Research Areas**

#### Minority Health and Health Disparities

- Characterize health disparities and underlying causes of these disparities in HLBS diseases and conditions
- Explore the 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, maternal morbidity and mortality and how diet and nutrition impact 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 the older old 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 (NHGRI) http://www.genome.gov/

Nutrition Research Spending (FY 2019):	\$9,899,408
Nutrition as Percentage of Total IC Obligations (FY 2019):	1.7%

#### OVERVIEW

Since the completion of the Human Genome Project in 2003, 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 multi-ethnic 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.

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 cognitive problems in older people. 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 our understanding of neural tube defects and potentially help guide public health policy in the area of nutritional supplementation. NHGRI intramural investigators are also conducting clinical and epidemiological research on patients with rare inborn errors of metabolism related to vitamin B12 metabolic pathways. They are creating animal models to study these conditions and are in early stages of developing a new gene therapy.

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. In the Mothers' TAKE study, NHGRI researchers have investigated how mothers' food choices for their children are affected by information about family history and obesity risk. The researchers are also looking at how genetic risk information influences mothers' feelings of guilt, factors associated with food choices

for boy or girl children, and how mothers' weight trajectories influenced their own health beliefs and attitudes. Results could suggest possible risks and benefits of integrating genetic risk messages into behavior change intervention approaches to promote optimal body weight in childhood.

NHGRI researchers are also studying the benefits, risks, and effects of providing genomics information about obesity into clinical weight-management encounters, with a focus on including stigmatized and underserved populations. The study is using simulations where overweight participants interact with a virtual reality physician, and researchers assess how this influences their attitudes, behaviors, and perceptions of stigmatization. The results could help inform ways that physicians can introduce genomic information into clinical care to encourage healthy behaviors.

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 Hispanics or Latinos, 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.

Finally, NHGRI investigators and NHGRI-funded investigators are also 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. These intramural researchers are also 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.

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### National Institute on Aging (NIA)

http://www.nia.nih.gov

Nutrition Research Spending (FY 2019):	\$172,484,624
Nutrition as Percentage of Total IC Obligations (FY 2019):	5.6%

#### OVERVIEW

Today, approximately 13.4% of Americans are age 65 years or over. By the year 2025, this number is expected to grow to over 20 percent as people continue to live longer, well into the eighth decade. The National Institute on Aging (NIA) supports basic, clinical, population-based, and translational research to advance our understanding of the nutritional influences on health and function as we age and to apply this information to the development of strategies (pharmacological and non-pharmacological) to promote healthy aging and extend years of productive life through improved health, 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) as well as conducted in the labs of NIA's Intramural Program—Laboratories of Epidemiology, Demography, and Biometry, Clinical Investigation, Cardiovascular Science, Molecular Biology and Immunology, and Experimental Gerontology, Genetics, Molecular Gerontology, Neurogenetics, Neuroscience, and Behavioral Neuroscience.

#### **RESEARCH DIRECTIONS**

NIA's priorities and future research directions on nutrition and aging are based on NIA staff evaluation of current research gaps, as well as input and recommendations from scientific advisors and NIA workshops. Topics of interest to the NIA and the Divisions most likely to be interested in these areas of research include:

- Bionutrition studies utilizing cellular and molecular techniques to identify the mechanisms of age-related changes in nutrient sensing, metabolism, homeostasis, and differential cell function (DAB)
- Effects of age on physiological processes through which nutrients, drugs, and other non-nutrient substances are absorbed, metabolized, and excreted in humans and in analogous animal models (DAB and DGCG)
- Basic and clinical studies of age-related changes in the nutritional requirements/dietary needs (DAB and DGCG)
- Nutritional status of older Americans and special subpopulations of older people at special nutritional risk such as those with multiple chronic conditions (DGCG)
- Effects of calorie reduction on age-related pathologies and/or longevity (DAB and DGCG)

- Effects of interventions in humans which involve different dietary patterns that affect the amount (i.e., caloric restriction), timing (e.g., intermittent fasting, time-restricted feeding), macronutrient composition (e.g., high-carbohydrate low-fat), or source (e.g., whole-food-plant-based) of food intake may affect the onset/treatment of age-related conditions and influence health span and life span (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 (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 (DN)
- Effect of diet, food extracts, and dietary supplements on cognition, sensory systems, and motor function (DN)
- General epidemiological studies and analysis of nutritional status, body composition, and their correlates with functional measures (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 (DBSR)
- Behavioral aspects of dietary change, including behavioral economics and mechanistic studies of behavior change related to diet and other health behaviors (DBSR)

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## National Institute on Alcohol Abuse and Alcoholism (NIAAA) http://www.niaaa.nih.gov/

Nutrition Research Spending (FY 2019):	\$24,844,078
Nutrition as Percentage of Total IC Obligations (FY 2019):	4.7%

#### OVERVIEW

The 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 the 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 FASD in children with prenatal alcohol exposure.
- Nutritional deficits from alcohol induced intestinal dysbiosis
- Interactions between alcohol mis-use on the gut microbiome and microbial effects in the gut-brain axis.

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## National Institute of Allergy and Infectious Diseases (NIAID) http://www.niaid.nih.gov/

Nutrition Research Spending (FY 2019):	\$68,342,792
Nutrition as Percentage of Total IC Obligations (FY 2019):	1.2%

#### OVERVIEW

Although 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, 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 co-infections and co-morbidities that accelerate the cycle of malnutrition and infection. Asthma and allergic diseases affect over 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 its relationship to nutrition in health and disease, the prevalence and control of acute respiratory infections and food-borne microbial illness, 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 inter-relationships of nutrition, immunity, and infection to expand knowledge that can be applied to develop improved diagnostic 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 co-morbidities (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 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, and cryptosporidiosis
- Relationship between diet, gut microbiota and autoimmune diseases
- The modulating effects of specific nutrients (e.g., vitamins, trace elements, fatty acids, fiber, and amino acids) and other ingredients such as probiotics/prebiotics on inflammatory pathways and immune function
- Immune responses, tolerance, and allergic reactions to specific foods such as milk, egg, and peanut
- Development and clinical testing of immunotherapeutic interventions to prevent and treat food allergies (e.g. AADCRCs: NCT00778258; NCT01157117).

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## National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS) http://www.niams.nih.gov/

Nutrition Research Spending (FY 2019):	\$19,650,561
Nutrition as Percentage of Total IC Obligations (FY 2019):	3.3%

#### OVERVIEW

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. Examples of ongoing nutrition research supported by NIAMS are as follows:

- Studies on the function of diets and nutrients in osteoarthritis, autoimmune diseases such as rheumatic arthritis and lupus, inflammation, and joint pain
- Dietary factors and risk of symptomatic knee osteoarthritis
- The role of dietary supplements in the risk of incident autoimmune disease and changes in biomarkers of systemic inflammation.
- The role of intensive diet and physical activity weight loss interventions on functional improvements among those with total knee replacement surgery, on pain improvements among those with osteoarthritis, and on fatigue in people with lupus.
- The relationship of diet quality and risk of rheumatoid arthritis and diet's potential role in reducing disease severity and histologic joint damage in people with rheumatoid arthritis
- Dietary approaches that regulate ketone body metabolism and their role in treatment of Gout.
- Research on nutritional regulation of muscle growth and repair
- Investigation of dietary risk factors for bone loss and dietary intervention to prevent bone fractures

#### CONTACT

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## National Institute of Dental and Craniofacial Research (NIDCR) http://www.nidcr.nih.gov/

Nutrition Research Spending (FY 2019):	\$18,149,596
Nutrition as Percentage of Total IC Obligations (FY 2019):	3.9%

#### 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 upon 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/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
- Impact of circulating maternal vitamin D on children's primary tooth development and dental caries experience
- 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/or plant extracts in regulating the inflammatory processes of periodontitis and rheumatoid arthritis
- 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
- Mechanisms by which taste and smell are integrated to impact the sensory experience of flavor and guide behavior

- Understanding the contribution of poor oral health to diet and sarcopenia in older age
- Effect of diet and nutrition upon erosive tooth wear

#### 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
- Association of factors such as an altered gut microbiome and nutritional deficiencies with adverse outcomes in HIV-exposed infants
- Dysbiosis of the subgingival microbiome and its impact upon periodontal disease development and progression
- Interaction between probiotic bacteria, oral microbiota and oral health promotion

#### 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
- Molecular mechanisms underlying diabetic oral wound healing and metabolic syndromeexacerbated periodontitis
- The oral microbiome in Type 1 diabetes and subclinical cardiovascular disease

#### 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 chemoradiation treatment for head and neck cancer
- Saliva microbiota dynamics and role in metformin-mediated oral squamous cell carcinoma prophylaxis

#### CONTACT

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# National Institute on Deafness and Other Communication Disorders (NIDCD) http://www.nidcd.nih.gov/

Nutrition Research Spending (FY 2019):	\$21,954,833
Nutrition as Percentage of Total IC Obligations (FY 2019):	4.6%

# OVERVIEW

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 us to use chemical signals to communicate with the environment and each other. For people, memories of taste and smell experiences are vivid and long lasting and play an important role in our 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 in which required nutrients were scarce and many plants contained poisonous, bitter compounds. Consequently, we 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 2 of every 3 adults are considered to be overweight or obese, and more than 1 of every 3 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 our 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 us determine new strategies to control overconsumption and improve health without reducing our 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 our understanding. For more detail, please refer to NIDCD's Strategic Plan for Research 2017-2021.

# 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 in order 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 and/or dysfunction resulting from radiation, chemotherapy, head trauma, and toxins.
- **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 which 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, the 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 the NIH.

### CONTACT

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# National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) http://www.niddk.nih.gov/

Nutrition Research Spending (FY 2019):	\$635,176,819
Nutrition as Percentage of Total IC Obligations (FY 2019):	30.3%

### OVERVIEW

Since its creation in 1950, NIDDK's 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 Nutrition Research and the Office of Obesity Research help coordinate 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

# **RESEARCH DIRECTIONS**

NIDDK fosters and supports nutrition research and training in multiple areas of basic, epidemiological, and clinical nutrition. Selected topics from the NIDDK nutrition research portfolio:

- 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 and/or status in humans throughout the lifespan, including smart devices for continuous monitoring of circulating nutrients, metabolites and hormones, identifying food specific molecular profiles and biomarkers of food and nutrient intake and dietary exposure, and mathematical models 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
- Evaluation of policy- and population-based approaches to improve nutrient/dietary intake or nutritional status.
- 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 to better understand 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.
- The identification of unrecognized roles of nutrients or their metabolites in health and disease
- Explore the impact of dietary modification on the human gut microbiome and/or dysregulation of gut microbiome on nutrient absorption, gut barrier function and permeability and metabolism.
- Development of Swallowable Smart Pills or Devices for Precision Nutrition, Microbiome and Digestive Disease
- Research to identify genes that influence human nutrition and nutrient metabolism, obesity, and nutritional disorders.
- Explore 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 and other chronic diseases
- Research to address how food insecurity effects 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 co-morbid 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. For more information, visit: https://www.niddk.nih.gov/research-funding/current-opportunities
- **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. For more information, visit: http://www.digestivediseasescenters.org/
- Mouse Metabolic Phenotyping Centers: The MMPC is a National Institutes of Health-sponsored resource that provides experimental testing services to scientists studying diabetes, obesity, diabetic complications, and other metabolic diseases in mice. For more information, visit: http://www.mmpc.org/
- NIDDK Diabetes Centers: NIDDK Diabetes Centers generate investigative resources that are available to the broader research community. Centers also provide short-term enrichment activities, as well as pilot and feasibility programs that fund small research grants designed to generate preliminary data for larger grant applications. For more information about each Diabetes Center's aims, shared resources, pilot and feasibility programs, enrichment programs, and activities, please visit their websites. For more information, visit: https://diabetescenters.org/
- Nutrition Obesity Research Centers: The NORC program supports 11 Centers providing research infrastructure, including research services, enrichment programs, and collaborative activities, at academic/medical institutions throughout the U.S. 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 and/or obesity and related research topics. For more information, visit: https://norccentral.org/
- **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. For more information, visit: https://www.niddk.nih.gov/research-funding/training-career-development

# **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 (NIDA) http://www.drugabuse.gov/

Nutrition Research Spending (FY 2019):	\$10,860,135
Nutrition as Percentage of Total IC Obligations (FY 2019):	0.7%

### OVERVIEW

NIDA's 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, and/or susceptibility to relapse.
- Identifying whether, and through what mechanisms, developmental exposure, including prenatal exposure, to specific nutrients modifies subsequent vulnerability for substance use disorders
- Determining 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 co-morbidity 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

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# National Institute of Environmental Health Sciences (NIEHS)

Nutrition Research Spending (FY 2019):	\$66,421,739
Nutrition as Percentage of Total IC Obligations (FY 2019):	7.8%

http://www.niehs.nih.gov/

### OVERVIEW

The mission of the National Institute of Environmental Health Sciences (NIEHS) is to discover how the environment affects people in order 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 and/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**

Applied Research

- Expand existing studies to look at the interplay between diet and health outcomes, including secondary data analysis in on-going 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 characterized 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 chemicals, nonchemical stressors, and 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, healthcare providers, and public health officials, who can translate evidence into credible and understandable information and actions that individuals and communities can use to decrease their risk, prevent harm, and improve their health

### **Basic Research**

- Identify pathways during critical life stages where the effects of dietary parameters will have the most pronounced effects on health outcomes
- 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/intervention studies
- Discover and explain how factors, including diet and medications along with the human microbiome, affect biological systems
- Study co-exposures related to food and nutrition to develop novel technological and quantitative approaches to prevent or intervene in adverse health impacts

### Examples of Nutrition Research Supported by NIEHS

- Nutrition, exercise, and the environment affect women's reproductive cycles
- Mechanistic role of P4501 enzymes in the prevention of PAH carcinogenesis by omega 3 fatty acids
- Silica-accelerated autoimmunity and the role of dietary lipids
- High animal fat diet consumed during puberty or young adulthood and breast cancer risk
- 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
- The role of microbe, including gut microbiota, in regulation of metabolism
- Genetic underpinning of diabetes associated with arsenic exposure
- Combined exposures to poor nutrition and chlorinated organics that lead to obesity, CVD, and diabetes
- Nutrients that modify the toxicity of methylmercury in a fish-eating population
- Ameliorating environmental risk factors for autism with folate supplements
- Preconception phthalate exposure and offspring outcomes
- Gamma tocopherol chemoprevention of wood smoke PM2.5-induced airway inflammation
- Promoting healthy seafood choices in Asian communities

- Identifying probiotic interventions that can enhance mercury excretion and reduce toxicity risk
- Prenatal air pollution, fetal development and early childhood obesity risk
- Health effects or toxicity of various dietary supplements such as Garcinia cambogia

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# National Institute of General Medical Sciences (NIGMS) http://www.nigms.nih.gov/

Nutrition Research Spending (FY 2019):	\$77,204,080
Nutrition as Percentage of Total IC Obligations (FY 2019):	2.7%

### OVERVIEW

The principal mission of 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

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 hence, serve to decrease morbidity and mortality.

# CONTACT

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# **National Institute of Mental Health (NIMH)**

http://www.nimh.nih.gov/index.shtml

Nutrition Research Spending (FY 2019):	\$38,135,532
Nutrition as Percentage of Total IC Obligations (FY 2019):	2.0%

### OVERVIEW

The mission of NIMH is to transform the understanding and treatment of mental illnesses through basic and clinical research, paving the way for prevention, recovery, and cure.

### **RESEARCH DIRECTIONS**

### The Eating Disorders Research Program

This program supports research on the etiology, core features, longitudinal course, and assessment of eating disorders. It also supports studies focusing on the elucidation of risk factors for the onset or recurrence of psychopathology. Intervention development studies to reduce the severity and incidence of eating disorders.

Areas of Emphasis

- Use of model systems, where appropriate, to test mechanistic pathways relevant to eating disorders.
- Elucidation of the neural trajectories of eating disorders (e.g., from pre-symptomatic to acute disease states [episodes and remissions], progression to chronic disease, remission or recovery, and relapse)
- Development and application of novel imaging approaches and computational methods for elucidating the neural bases of symptoms, cognitive, and behavioral features of eating disorders
- Identify mechanisms (e.g., genetic, biological, behavioral, environmental) that confer vulnerability to eating disorders and develop early interventions (pharmacological, device based, and/or psychosocial) for reducing the severity and incidence of eating disorders
- Effectiveness research focused on optimizing preventive and therapeutic interventions for eating disorders and commonly occurring comorbid conditions (e.g., refining therapies to increase potency and efficiency; testing strategies for matching and sequencing treatments)
- Services research that aims to improve service use (e.g., access to treatment, engagement and continuity in services) and service delivery (e.g., equity, efficiency, and quality of mental health care) for individuals with eating disorders.

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# National Institute on Minority Health and Health Disparities (NIMHD) http://www.nimhd.nih.gov/

Nutrition Research Spending (FY 2019):	\$34,254,223
Nutrition as Percentage of Total IC Obligations (FY 2019):	8.8%

### OVERVIEW

NIMHD leads scientific research to improve minority health and reduce health disparities. NIMHD works independently and in partnership with other NIH Institutes, Centers, Offices, other federal agencies, and community organizations to:

- Plan, coordinate, review, and evaluate NIH minority health and health disparities research and activities
- Conduct and support research on minority health and health disparities
- Promote and support the training of a diverse research workforce
- Translate and disseminate research information
- Foster innovative collaborations and partnerships

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 (SGM), and underserved rural populations continue to experience a disproportionate burden of illness, disability, and premature death. Poor nutrition can impact people for a lifetime and may contribute to health disparities across many populations. Health disparities in cardiovascular disease, cancer, infant mortality, obesity-associated outcomes, asthma, diabetes, and stroke may all be impacted by nutrition.

The higher prevalence of morbidity, poor outcomes, and chronic diseases, including diabetes, hypertension, cardiovascular disease, and certain cancers experienced by African Americans or Blacks, American Indians and Alaska Natives, and Hispanics or Latinos are substantially greater compared to Whites. Native Hawaiians and Pacific Islanders also have a higher prevalence of diabetes and obesity in comparison to Whites. These are conditions that are influenced by nutrition and diet-related behaviors. Limited research has been conducted on the biological and genetic bases for these disparities, which may provide further understanding about the causes of these disparities among racial and ethnic populations. 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 biological, genetic, socioeconomic, environmental, cultural, and structural differences that exist between racial and ethnic minorities and Whites perpetuate these nutrition-related health disparities. Conducting further research to enhance insights into the health determinants associated with these disparities can advance our understanding and development of culturally appropriate solutions for these nutrition-related health disparities.

### **RESEARCH DIRECTIONS**

NIMHD supports nutrition research that examines the causes, treatment, and prevention of diseases disproportionately impacting health disparity populations. The following are selected examples of NIMHD's nutrition-related projects supported during FY2017-FY2019:

### Mechanisms and Risk Factors

- Epigenetic and Biobehavioral Determinants of Preterm Birth in Black Women: Investigates whether specific biobehavioral factors linked to pre-term birth (PTB) influence the epigenetic regulation of genes to promote PTB in African American women, including poor nutritional status, stress, and reproductive tract infections. (5R01MD009064-04)
- **Obesity and Caries in Young South Asian Children: A Common Risk Factor Approach:** Targets risk factors for childhood caries and obesity using a multi-level intervention. (5R01MD010460-02).
- A Cohort for Studying the Burden of Cardiometabolic Diseases in Guam and Pohnpei: Focuses on cardiometabolic risk factors to: a) estimate the prevalence of non-communicable diseases and lifestyle factors such as acculturation, alcohol, betel nut consumption, diet, hypertension, obesity, physical activity, sleep, stress, and tobacco use; b) estimate the prevalence of diabetes mellitus and dyslipidemia, and c) validate the association of diabetes mellitus and acanthosis nigricans. (5U24MD011201-02)
- **The Vaginal Microbiome and Racial Disparity in Preterm Delivery:** Seeks to identify factors influencing the vaginal microbiome profiles of African American and White women in the Pregnancy, Infection, and Nutrition study. This research examines the influence of innate spontaneous preterm birth (sPTB) risk factors on vaginal microbiome profiles; and the influence of exogenous risk factors for sPTB on vaginal microbiome profiles such as maternal nutritional patterns. (1R01MD011504-01A1).
- Impact of Navajo Nation Tax on Junk Food: Examines significant gaps in data and knowledge with a focus on the impact of the Navajo Nation junk food tax in reducing obesity rates. The project assesses the overall impact of changes in the food store environment and behaviors, including consumption of sugar-sweetened beverages, and fruits and vegetables on obesity rates as a result of tax revenues from junk food. (1R01MD013352-01)
- Low Cost Point-of-Care Diagnostic to Address Community Vitamin D Health Disparities: Develops, optimizes, and conducts proof-of-concept studies for an affordable and quick vitamin D assay that can be used in retail pharmacies and health clinics for easy assessment of vitamin D status. This study will help to address the Vitamin D disparity among African Americans or Blacks, Mexicans, and Whites. (1R43MD013409-01A1)
- The Effect of Food Marketing and Attentional Biases on Eating Behaviors in African American Adolescent Girls: Evaluates whether food marketing and attentional biases individually impact food consumption among African American adolescent girls. (5F31MD010675-02)

### Intervention and Translation Research

- **Cheyenne River Sioux Tribe Cooking for Health:** Develops, implements, and evaluates a culturally-targeted healthy foods budgeting, purchasing, and cooking skills intervention aimed at improving the cardiometabolic health of American Indians with type 2 diabetes who live in rural areas. (1R01MD011596-01A1)
- **SANOS (SAlud y Nutrición para todOS):** Optimizes a culturally and linguistically tailored diet and lifestyle intervention addressing obesity, cardiovascular disease and cancer risk, to determine which obesity components of the intervention will contribute most to decreasing weight among underserved U.S. Mexicans. (1R01MD012819-01)
- Healthy Lifestyle Intervention for High-Risk Minority Pregnant Women: A RCT: Aims to improve healthy lifestyle behaviors (nutrition and exercise), psychosocial health, birth and post-natal outcomes in pregnant emotionally distressed African American or Black women. (1R01MD012770-01A1)

# Prevention

- Effects of Functional Food Diets on Cardiometabolic and Metabolomics Profiles in Minority Youth: Examines the effects of adapting a personalized functional food diet at earlier life stages on carbohydrate and lipid regulation pathways, in minority youth (Asian and African American or Black) at risk for developing cardiometabolic disorders compared to White youth at risk. The study also will investigate the effects of almonds on blood glucose regulation pathways using metabolomics techniques. (1K99MD012815-01)
- Community-Based Dietary Approach for Hypertensive African Americans with Chronic Kidney Disease: Seeks to determine whether delivering nutritional advice to adopt the Dietary Approaches to Stop Hypertension (DASH) diet and \$30 per week worth of fruits and vegetables, tailored to personal choices and availability in neighborhood stores, will reduce blood pressure and kidney damage in socioeconomically disadvantaged African Americans with hypertension and chronic kidney disease. (5U01MD010550-02)
- IoT-Based Smart-Toilet and Mobile App for Passively Quantifying Objective Urinary Biomarkers of Dietary Intake and Personalizing Nutrition Guidance: Integrates multiplexed biosensor technology into an Internet of Things (IoT)-based smart-toilet at home for passive, dietary monitoring, and will provide personalized nutrition recommendations using a mobile app accessible to individuals in rural and low socioeconomic communities. (1R43MD014073-01)

# Nutrition Education/Outreach

- **Good Bowls: Empowering Communities to Achieve Good Food Access and Health Equity:** Aims to address food insecurity and nutrition by creating healthy and affordable frozen meals for sale in local corner stores using food from local farmers produced in local commercial kitchens and sold at a subsidized price. (1R41MD014075-01)
- Lowering the Impact of Food insecurity in African American Adults with Type 2 Diabetes Mellitus (LIFT-DM): Tests whether monthly food vouchers to farmers market or monthly mailed food stock boxes or the combination of both, layered upon diabetes education will lead to improvements in glycemic control in low income, food insecure, African Americans with type 2 diabetes. (1R01MD013826-01)

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# National Institute of Neurological Disorders and Stroke (NINDS) http://www.ninds.nih.gov/

Nutrition Research Spending (FY 2019):	\$31,683,198
Nutrition as Percentage of Total IC Obligations (FY 2019):	1.3%

# 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. NINDS nutrition research supports studies examining the role of specific nutrients in a number of neurological disorders and in neuronal injury. Most studies focus on understanding the molecular and cellular mechanisms by which nutrient deficiency or metabolic conditions lead or contribute to changes in neural function and testing the effects of nutritional supplements or modified metabolic pathways in animal models of neurological diseases. Major areas of nutrition research currently funded by NINDS include:

- Exploring the role of the gut microbiome in neurological disorders such as traumatic brain injury, spinal cord injury, and Parkinson's disease, to study how the gut microbiome—often influenced by nutrition and diet—may modulate the immune system and neural function
- Exploring the link between diet/nutrition and brain health by supporting epidemiological studies that are assessing the effects of diet/nutrition and other lifestyle factors on stroke, stroke risk, and cognitive decline later in life
- Investigating the role of nutrients in brain health and development, and studying how nutrient deficiency or metabolic conditions such as obesity, hyperhomocysteinemia, phenylketonuria, or diabetes, can contribute to impaired neural function and neurological diseases
- Understanding how cellular energy metabolism affects brain function to help identify novel drug targets involved in metabolic pathways, and investigating the relationship between neural function and metabolism to better understand the mechanisms by which neurological conditions may lead to disrupted metabolism

• Investigating neurological mechanisms underlying dietary interventions (e.g., ketogenic diet, dietary supplements, etc.) or treatments that target metabolic pathways in animal models of neurological diseases, including traumatic brain injury, stroke, cerebrovascular disease, Alzheimer's disease, Parkinson's disease, multiple sclerosis, and epilepsy

### CONTACT

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# National Institute of Nursing Research (NINR) http://www.ninr.nih.gov/

Nutrition Research Spending (FY 2019):	\$16,045,979
Nutrition as Percentage of Total IC Obligations (FY 2019):	9.8%

### OVERVIEW

The mission of the National Institute of Nursing Research (NINR) is to promote and improve the health of individuals, families, and communities. To achieve this mission, NINR supports and conducts clinical and basic research and research training on health and illness, research that spans and integrates the behavioral and biological sciences, and that develops the scientific basis for clinical practice. The NINR Strategic Plan is available at: www.ninr.nih.gov/AboutNINR/NINRMissionandStrategicPlan/.

# **RESEARCH DIRECTIONS**

NINR views nutrition as an essential component of health promotion, disease prevention, and selfand symptom management; and, as such, supports a broad range of research in the science of nutrition. The nutrition research portfolio at NINR crosses the spectrums of disease, populations, and the lifespan. Recent examples of research areas include studies elucidating the effects of nutrition in gestation, including conditions such as pre-eclampsia; examining breastfeeding outcomes and feeding difficulties in pre-term infants and their growth and long-term health outcomes; designing and testing tailored, nutritional interventions for low income and diverse populations; exploring nutritional connections and molecular mechanisms in abdominal and gastrointestinal pain for children and adults; implementing nutrition interventions in diabetes and kidney disease management; and, developing and testing a variety of interventions for prevention and treatment of obesity and cardiovascular disease. NINR has co-sponsored several nutrition-related funding announcements 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 encourages R01 applications to improve health outcomes for women, infants and children, by stimulating interdisciplinary research focused on maternal nutrition and pre-pregnancy obesity; PA-18-355 Healthy Habits: Timing for Developing Sustainable Healthy Behaviors in Children and Adolescents which seeks to encourage applications that employ innovative research to identify mechanisms of influence and/or promote positive sustainable health behavior(s) in children and youth (birth to age 21); and has signed on to PAR-18-857 Diet and Physical Activity Assessment Methodology which encourages innovative research to enhance the quality of measurements of dietary intake and physical activity.

These studies highlight NINR's long-term commitment to health promotion, patient empowerment in the management of illness and recovery, and the reduction of disease and disability. Findings from these studies will add to the growing body of literature related to nutrition.

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# Office of Dietary Supplements (ODS) http://ods.od.nih.gov/

Nutrition Research Spending (FY 2019):	\$13,750,758
Nutrition as Percentage of Total IC Obligations (FY 2019):	42%

# OVERVIEW

The mission of the ODS at the National Institutes of Health (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 2018, Americans spend over \$46 billion per year 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 the U.S. Department of Health and Human Services (HHS), which 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.

# **EXAMPLE OF ODS ACTIVITIES:**

# **Research Support**

The majority of the ODS budget supports research on dietary supplements in collaboration with many NIH Institutes and Centers. For FY2019 ODS provided \$10.4 million in co-funding 59 grants across 13 NIH institutes and centers. 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. http://ods.od.nih.gov/Research/funding.sec.aspx

**Centers for Advancing Research on Botanical and Other Natural Products (CARBON) Program** Since 1999, in partnership with the National Center for Complementary and Integrative Health, 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. http://ods.od.nih.gov/Research/Dietary\_Supplement\_Research\_Centers.aspx

### **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. http://ods.od.nih.gov/Research/AMRMProgramWebsite.aspx

#### 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:

- ODS Research Scholars Program: http://ods.od.nih.gov/Research/Training.aspx
- Mary Frances Picciano Dietary Supplements Research Practicum: https://ods.od.nih.gov/Research/dsrp.aspx

#### **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. https://ods.od.nih.gov/Research/populationstudies.aspx

#### **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 Iniative 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. https://ods.od.nih.gov/Research/Iodine.aspx

### **Dietary Supplement Ingredient and Label Databases**

The Dietary Supplement Ingredient Database (DSID), developed by the 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. https://dietarysupplementdatabase.usda.nih.gov/

The Dietary Supplement Label Database (DSLD), 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 DSLD. https://ods.od.nih.gov/Research/Dietary\_Supplement\_Label\_Database.aspx

### Communications

ODS develops and disseminates information about the latest science on dietary supplements for a wide range of audiences including researchers, healthcare providers, industry, and consumers. This information is provided through the ODS website, fact sheets, e-newsletters, and staff presentations at professional and consumer-focused meetings.

- Supplement fact sheets: https://ods.od.nih.gov/HealthInformation/makingdecisions.sec.aspx
- To sign up for the listserv: https://ods.od.nih.gov/News/ODS\_ListServ.aspx

### 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.
- Computer Access to Research on Dietary Supplements (CARDS): This searchable database provides information on federally funded research projects pertaining to dietary supplements.
- Dietary Supplement Ingredient Database (DSID): This database provides the amount of nutrients in some dietary supplements based on chemical analysis.
- Dietary Supplement Label Database (DSLD): 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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