From the American Society for Nutrition

Strengthening national nutrition research: rationale and options for a new coordinated federal research effort and authority

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ABSTRACT

Background: The US faces remarkable food and nutrition challenges. A new federal effort to strengthen and coordinate nutrition research could rapidly generate the evidence base needed to address these multiple national challenges. However, the relevant characteristics of such an effort have been uncertain.

Objectives: Our aim was to provide an objective, informative summary of *1*) the mounting diet-related health burdens facing our nation and corresponding economic, health equity, national security, and sustainability implications; *2*) the current federal nutrition research landscape and existing mechanisms for its coordination; *3*) the opportunities for and potential impact of new fundamental, clinical, public health, food and agricultural, and translational scientific discoveries; and *4*) the various options for further strengthening and coordinating federal nutrition research, including corresponding advantages, disadvantages, and potential executive and legislative considerations.

Methods: We reviewed government and other published documents on federal nutrition research; held various discussions with expert groups, advocacy organizations, and scientific societies; and held in-person or phone meetings with >50 federal staff in executive and legislative roles, as well as with a variety of other stakeholders in academic, industry, and nongovernment organizations.

Results: Stark national nutrition challenges were identified. More Americans are sick than are healthy, largely from rising diet-related illnesses. These conditions create tremendous strains on productivity, health care costs, health disparities, government budgets, US economic competitiveness, and military readiness. The coronavirus disease 2019 (COVID-19) outbreak has further laid bare these strains, including food insecurity, major diet-related comorbidities for poor outcomes from COVID-19 such as diabetes, hypertension, and obesity, and insufficient surveillance on and coordination of our food system. More than 10 federal departments and agencies currently invest in critical nutrition research, yet with relatively flat investments over several decades. Coordination also remains suboptimal, documented by multiple governmental reports over 50 years. Greater harmonization and expansion of federal investment in nutrition science, not a silo-ing or rearrangement of existing investments, has tremendous potential to generate new discoveries to improve and sustain the health of all Americans. Two identified key strategies to achieve this were as follows: *1*) a new authority for robust cross-governmental coordination of nutrition research and other nutrition-related policy and *2*) strengthened authority, investment, and coordination for nutrition research within the NIH. These strategies were found to be complementary, together catalyzing important new science, partnerships, coordination, and returns on investment. Additional complementary actions to accelerate federal nutrition research were identified at the USDA.

Conclusions: The need and opportunities for strengthened federal nutrition research are clear, with specific identified options to help create the new leadership, strategic planning, coordination, and investment the nation requires to address the multiple nutrition-related challenges and grasp the opportunities before us. *Am J Clin Nutr* 2020;00:1–49.

Keywords: federal nutrition research, *Dietary Guidelines for Americans*, Dietary Reference Intakes, nutrition, diet, policy, research, prevention

Executive Summary

Aims

This white paper aims to evaluate key issues relevant to federal nutrition research, including the following:

1) The mounting diet-related health burdens and corresponding economic, health equity, national security, and sustainability implications;

2) The current diverse federal nutrition research landscape and existing mechanisms for its coordination;
3) The opportunities for new nutrition-related discoveries in fundamental, clinical, public health, food and agricultural, and translational scientific research; and
4) The best strategies to further strengthen and coordinate federal nutrition research, including advantages, disadvantages, and potential paths forward.

This effort, informed by extensive background research and interviews, is intended to invite comment and discussion from all key stakeholders and help lay the foundation for accelerated scientific advances in nutrition to improve and sustain the health of all Americans.

The burden

Diet-related illnesses are the leading source of poor health in the US. Nearly 3 in 4 American adults are overweight or obese, and 1 in 2 have diabetes or prediabetes—and these rates continue to rise. Poor nutrition further contributes to cardiovascular diseases, several cancers, poor gut health, and many other disorders. Beyond effects on health, these diet-related diseases create enormous strains on productivity, health care spending, health disparities, and military readiness (**Figure 1**). Our food system also strains our natural resources, a crucial new area of intersecting science and policy.

Profound disparities in both diet-related chronic diseases and food insecurity, for example, are experienced by low-income, rural, minority, and other underserved populations. Nearly 3 in 4 young Americans do not qualify for military service, with obesity being the leading medical disqualifier. Obesity and other diet-related chronic diseases are endemic among veterans, while obesity and food insecurity coexist in many active-duty military families. Over just 50 y, federal health care spending has risen from 5% to 28% of the federal budget, while US business (inflation-adjusted) spending on health care has increased from $79 billion to $1180 billion. Approximately 85% of current health care spending is related to management of diet-related chronic diseases. Estimated US government expenditures on direct medical care for diabetes alone (~$160 billion/y) exceeds the annual budgets of many individual federal departments and agencies, including, among others, the Departments of Education (DoE), Homeland Security (DHS), and Justice (DoJ) and the NIH, CDC, Environmental Protection Agency (EPA), and FDA.

These strains have been further exposed and exacerbated by coronavirus disease 2019 (COVID-19). This includes, for example, challenges related to hunger and food insecurity, major diet-related comorbidities for poor outcomes from COVID-19, insufficient evidence on optimal population resilience through better nutrition, and inadequate surveillance and coordination of our food system.

Addressing each of these issues requires a better understanding of their multilevel, interrelated biological, individual, social, and environmental determinants, and the corresponding translational solutions. However, the current scope and pace of nutritional knowledge and discovery are insufficient to address the fundamental nutrition-related challenges facing the nation.

The current landscape

More than 10 federal departments and agencies currently invest in critical nutrition research. Their relative investments in nutrition research have remained flat or declined over several decades—even as diet-related conditions and their societal burdens have climbed. The NIH is the largest funder, with

Supported by the Rockefeller Foundation (award number: 2019 FOD 011). The views expressed herein do not necessarily represent the views of the funders or Tufts University.

Supplemental Figures 1–9, Supplemental Tables 1–10, and Supplemental Text 1–3 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/ajcn/.

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Abbreviations used: AHRQ, Agency for Healthcare Research and Quality; ARS, USDA Agricultural Research Service; BRAIN, NIH Brain Research through Advancing Innovative Neurotechnologies; CHAMP, Consortium for Health and Military Performance; CMMI, HHS Center for Medicare and Medicaid Innovation; CMS, HHS Centers for Medicare and Medicaid Services; CNPP, USDA Center for Nutrition Policy and Promotion; COVID-19, coronavirus disease 2019; DGA, *Dietary Guidelines for Americans*; DGAC, Dietary Guidelines Advisory Committee; DHS, Department of Homeland Security; DNRC, NIH Division of Nutrition Research Coordination; DoC, Department of Commerce; DoD, Department of Defense; DoE, Department of Education; DoJ, Department of Justice; DPC, Domestic Policy Council; DPCPSI, NIH Division of Program Coordination, Planning, and Strategic Initiatives; EPA, Environmental Protection Agency; ERS, USDA Economic Research Service; FEMA, Federal Emergency Management Agency; FNS, USDA Food and Nutrition Service; FTC, Federal Trade Commission; GAO, Government Accountability Office; GDP, Gross Domestic Product; HHS, Department of Health and Human Services; HNCC, USDA Human Nutrition Coordinating Committee; HNRIM, Human Nutrition Research and Information Management; IBNMRR, Interagency Board for Nutrition Monitoring and Related Research; ICHNR, Interagency Committee on Human Nutrition Research; JSHNR, Joint Subcommittee on Human Nutrition Research; MND, Military Nutrition Division; NASA, National Aeronautics and Space Administration; NASEM, National Academies of Sciences, Engineering, and Medicine; NCC, NIH Nutrition Coordinating Committee; NCI, National Cancer Institute; NCNR, proposed NIH National Center for Nutrition Research; NHLBI, NIH National Heart, Lung, and Blood Institute; NIDDK, NIH National Institute of Diabetes and Digestive and Kidney Diseases; NIFA, USDA National Institute of Food and Agriculture; NIMHD, NIH National Institute of Minority Health and Health Disparities; NINR, NIH National Institute of Nursing Research; NIN, NIH new National Institute of Nutrition; NNMRRP, National Nutrition Monitoring and Related Research Program; NSC, National Security Council; NSF, National Science Foundation; OCS, USDA Office of the Chief Scientist; ODNI, Office of the Director of National Intelligence; ODPHP, HHS Office of Disease Prevention and Health Promotion; OMB, White House Office of Management and Budget; ONDFN, New Office of the National Director of Food and Nutrition; ONR, NIDDK Office of Nutrition Research; OSTP, White House Office of Science and Technology Policy; RCDC, Research, Condition, and Disease Categorization; REE, USDA Research, Economics, and Education mission area; RePORTER, NIH Research Portfolio Online Reporting Tools Expenditures and Results; ROI, return on investment; SNAP, USDA Supplemental Nutrition Assistance Program; SNAP-Ed, USDA Supplemental Nutrition Assistance Program Education; USAID, US Agency for International Development; USGCRP, US Global Climate Research Program; USGNRP, New US Global Nutrition Research Program; VA, Department of Veterans Affairs; VHA, Veterans Health Administration; WIC, USDA Special Supplemental Nutrition Program for Women, Infants, and Children.

Received May 17, 2020. Accepted for publication June 11, 2020.
First published online 0, 2020; doi: https://doi.org/10.1093/ajcn/nqaa179.

FIGURE 1 Examples of identified diet-related burdens that could be addressed by more coordinated and strengthened federal nutrition research. COVID-19, coronavirus disease 2019. Graphic design support courtesy of Ink&Pixel Agency.

nutrition research investments estimated at $1.9 billion annually (~5% of total NIH funding) for fiscal year 2019. Approximately 25% of this funding (1.3% of total NIH funding) focuses on diet for the prevention or treatment of disease in humans. This NIH nutrition research is conducted and supported across nearly all of the 27 current NIH institutes and centers. Coordination of these efforts has been challenged by successively smaller NIH coordinating offices with decreasing stature, staff, and resources. The USDA is the second-largest funder of US nutrition research, with an estimated annual budget of ~$0.17 billion for fiscal year 2019 across several institutes and services. The USDA works to provide Americans with safe, nutritious, and wholesome food and works to ensure the foods and beverages our nation produces optimally benefits human and animal health and to address food insecurity through the administration of 15 federal nutrition assistance programs. Several structures work to improve research coordination within the USDA, although a recent USDA workshop and Government Accountability Office (GAO) report identified gaps and opportunities in nutrition research coordination. Multiple other federal departments and

agencies invest in nutrition research, including the CDC, FDA, Department of Defense (DoD), US Agency for International Development (USAID), Department of Veterans Affairs (VA), National Aeronautics and Space Administration (NASA), and others.

Consistent with this fragmented infrastructure, multiple major reports over 50 y have called for greater coordination of federal nutrition research. Current coordination efforts include the Interagency Committee on Human Nutrition Research (ICHNR), which currently meets about twice a year to work on the following activities, among others: food and nutrition monitoring and surveillance, the joint USDA–Department of Health and Human Services (-HHS) activity to produce the *Dietary Guidelines for Americans* (DGAs) and certain regulatory, communication, and educational activities. However, no concrete authority has been created to successfully harmonize and leverage the federal investments in nutrition research.

Overall, this white paper and several prior reports found these efforts to be important but insufficient to address current and rising diet-related disease burdens, food insecurity, health disparities, health care costs, challenges to military readiness, and intersections with food and agricultural production, supply chains, and sustainability.

The opportunity

Several specific priority areas in nutrition research have been identified by various federal and nongovernmental organizations. However, most have not been adequately addressed. Greater federal coordination and investment in nutrition research could accelerate discoveries across these critical areas (**Figure 2**).

Several lines of evidence support a strong return on investment (ROI) for an expanded and coordinated nutrition research effort. As stated by the FDA Commissioner in 2018 at the National Food Policy Conference, "Improvements in diet and nutrition offer us one of our greatest opportunities to have a profound and generational impact on human health …. The public health gains of such efforts would almost certainly dwarf any single medical innovation or intervention we could discover."

The options

Any new federal nutrition research investment and coordination structure must leverage, harmonize, and catalyze the existing efforts being led across multiple federal departments and agencies. Two major complementary strategies were identified: *1*) a new authority for robust cross-governmental coordination of nutrition research and other nutrition-related policy and *2*) strengthened authority, investment, and coordination for nutrition research within the NIH.

Specific promising options to advance these 2 strategies were identified (**Box 1**); and for each option, potential advantages and disadvantages, executive and legislative considerations, and paths forward are discussed. Improved coordination between federal departments and agencies conducting nutrition research was identified as having tremendous potential for accelerating essential basic, clinical, public health, and translational discoveries. Increased authority, coordination, and funding for nutrition science within NIH was also identified as being essential for accelerating needed discoveries. Appropriate efforts should leverage and amplify, not replace, compete with, or isolate existing nutrition research efforts across NIH, USDA, or other departments and agencies. The cross-government strategy and within-NIH strategy were identified as complementary, with benefits accruing independently and further synergies to be gained by joint implementation.

Box 1

Promising cross-governmental and NIH options to strengthen and accelerate national nutrition research[1]

Cross-governmental

- A new Office of the National Director of Food and Nutrition (ONDFN)
- A new US Global Nutrition Research Program (USGNRP)
- A new Associate Director for Nutrition Science in the White House Office of Science and Technology Policy (OSTP)
- A new US Task Force on Federal Nutrition Research

Within NIH

- A new National Institute of Nutrition (NIN)
- A new National Center for Nutrition Research (NCNR)
- A return of the Office of Nutrition Research (ONR) into the NIH Office of the Director
- Development of new trans-NIH initiatives in nutrition research

Within USDA

- Increased investment in nutrition research across the USDA Research, Education, and Economics mission area
- Expanded USDA research to improve public guidance and education
- Innovative USDA research to strengthen benefits of nutrition assistance programs

[1]Additional relevant priorities to strengthen federal nutrition research within other departments and agencies, such as DoD, USAID, and FDA, were recognized and should be the subject of future reports.

Further complementary actions to accelerate federal nutrition research were identified at USDA. First, to increase investment in nutrition research for the Agricultural Research Service (ARS) including its network of Human Nutrition Research Centers, the National Institute of Food and Agriculture (NIFA) extramural research programs, and the Economic Research Service (ERS) programs, which assesses demographic, social, informational, and economic determinants of dietary consumption and associated health outcomes. Second, to expand USDA research that evaluates and improves major ongoing efforts for public guidance and education on nutrition. And third, to build the robust evidence base and collaborations needed to strengthen the positive impacts of the ~$100 billion/y federal investments in nutrition assistance programs.

Conclusions

This white paper identified many stark and growing national challenges related to nutrition. Our research further documented a diversity of federal investments in nutrition research across

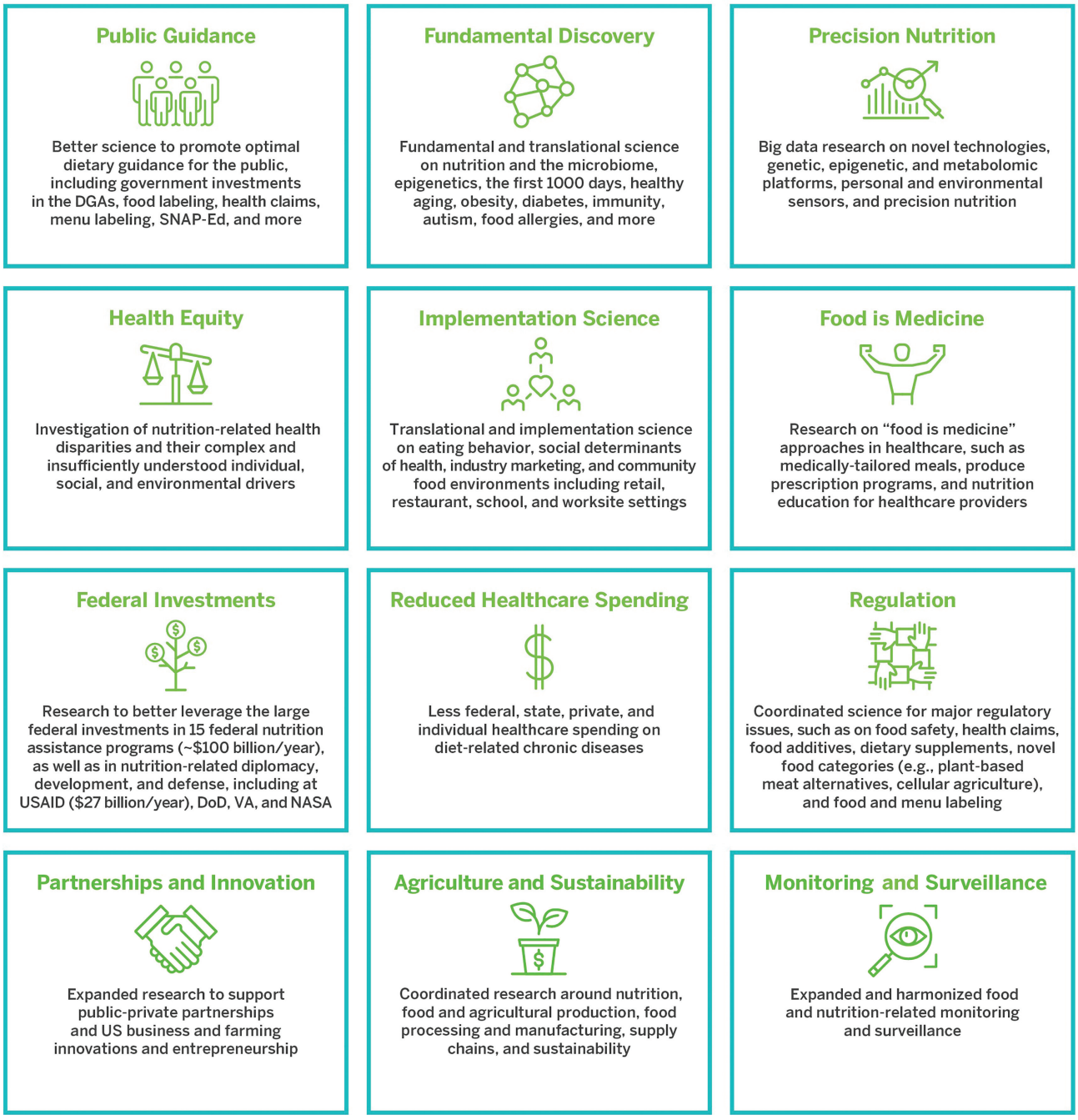

FIGURE 2 Opportunities for enhanced federal nutrition research coordination and investment. DGAs, *Dietary Guidelines for Americans*; DoD, Department of Defense; NASA, National Aeronautics and Space Administration; SNAP-Ed, USDA Supplemental Nutrition Assistance Program Education; USAID, US Agency for International Development; VA, Department of Veterans Affairs. Graphic design support courtesy of Ink&Pixel Agency.

departments and agencies, but with flat or declining funding and with suboptimal coordination authority. The opportunities to be gained by greater coordination and investment in federal nutrition research are clear, with potential for large and rapid ROI. This white paper identified and described 2 priority strategies, including *1*) a new authority for cross-governmental coordination and *2*) strengthened authority, investment, and coordination within NIH. Additional important strategies were also identified at USDA. All these strategies were found to be complementary, providing independent as well as synergistic benefits. The identified specific options would help create the new leadership, strategic planning, coordination, and investment the nation requires to address the multiple nutrition-related challenges before us, and grasp the corresponding opportunities.

Introduction

The US faces remarkable food and nutrition challenges. More Americans are sick than are healthy, with diet-related illnesses playing a major role including obesity, type 2 diabetes, cardiovascular diseases, cancers, food allergies, and more (1). The incidence and prevalence of many of these conditions have increased dramatically in recent decades. In addition to burdens on health and productivity, these diet-related diseases are creating tremendous strains on health care spending, health disparities, government budgets, economic competitiveness of American businesses, and military readiness. Innovations in food and nutrition should improve human health while also preserving our natural resources, a crucial new area of intersecting science and policy.

Many of these strains in food and nutrition have been further exposed and exacerbated by COVID-19 (2). This includes, for example, challenges related to hunger and food insecurity; major diet-related comorbidities for hospitalization and death from COVID-19 such as diabetes, obesity, and hypertension; insufficient evidence on optimal population resilience through better nutrition; and the need to further improve the surveillance on and coordination of food production and supply chains (3–9).

While advancing nutrition research has provided evidence to describe the general contours of healthy eating patterns, it has also highlighted many critical new, unanswered questions on food and nutrition and the national challenges we face (10). Important nutrition research is currently being supported by >10 federal departments and agencies (11). Yet, as diet-related conditions and their societal burdens have climbed in recent decades, funding for such research has remained flat (12). In addition, no concrete action has emerged to successfully harmonize and leverage nutrition research across the government, despite consistent recommendations over at least 5 decades for a robust coordinating federal entity (13). A major, new federal effort to strengthen and coordinate nutrition research could rapidly generate the necessary evidence base to address multiple national challenges, providing major benefits and ROI.

The aim of this white paper is to evaluate key issues relevant to such a scientific effort, including the following:

1) The mounting diet-related health burdens facing our nation and the corresponding economic, health equity, national security, and sustainability implications;
2) The current federal nutrition research landscape and existing mechanisms for its coordination among the diverse departments and agencies working to address these challenges;
3) The opportunities for and potential impact of new fundamental, clinical, public health, food and agricultural, and translational scientific discoveries related to nutrition; and
4) The best strategies to further strengthen and coordinate federal nutrition research, including relevant advantages, disadvantages, and potential executive and legislative considerations for a path forward.

This white paper is intended to invite comment and discussion from all stakeholders who care about strengthening nutrition research, whether to improve health, lower public and private health care spending, reduce disparities, promote business innovation, reinvigorate rural communities, preserve our national resources, or strengthen national security. Key audiences for this white paper include the following:

- Elected and appointed federal officials in both executive and legislative branches;
- Federal science agency leaders and program and policy staff;
- Federal military leadership;
- The academic community;
- Clinical and scientific professional organizations;
- Nonprofit advocacy groups;
- Allied health professional organizations;
- US businesses whose efforts, employees, and competitiveness can be benefited by federally supported nutrition discoveries;
- The media, who communicate key nutrition-related messages; and
- The public who rely on and desperately need advances in federally supported nutrition research to help improve and sustain their health and communities.

This white paper was informed by extensive background research and stakeholder conversations. This research included a review of government and other published documents on federal nutrition research; discussions with expert groups, advocacy organizations, and scientific societies; and in-person or phone meetings with >50 federal staff in executive and legislative roles, as well as with a variety of extramural researchers in academic and nongovernmental organizations. The writing group reached out to all 10 departments and agencies participating in the ICHNR, particularly for assistance in estimating their relevant budget for nutrition research. The legislative history for the NIH was independently collected by 2 team members with high agreement. Legal experts at the Center for Health Law and Policy Innovation at Harvard Law School reviewed this white paper with special attention to the section on Options and the corresponding legislative and executive considerations. We also reviewed feedback received through the American Society for Nutrition (ASN) request for member input regarding the concept of a National Institute of Nutrition and through a related panel session and Q&A at the ASN Nutrition 2019 annual scientific conference. We also sought input from members of the Nutrition Action Alliance (NAA), a coalition of organizations working to advance federal nutrition research, nutrition education, and nutrition monitoring and surveillance, among other activities, and which includes ASN, Academy of Nutrition and Dietetics, American Society for Parenteral and Enteral Nutrition, Association of Nutrition Departments and Programs, Institute of Food Technologists, National Board of Physician Nutrition Specialists, Society for Nutrition Education and Behavior, and The Obesity Society. The writing group used these document reviews, one-on-one conversations, stakeholder interviews, and additional discussions to maximize candid, confidential reflections following Chatham House Rules on the past and present state of federal nutrition research, the challenges and opportunities, and the best available strategies for moving forward.

We hope this white paper provides an objective, informative summary of the *1*) burdens, *2*) current federal nutrition research landscape, *3*) opportunities, and *4*) options for strengthening national nutrition research. Ultimately, we hope it helps lay the

foundation for accelerated advances in nutrition research to help improve and sustain the health of all children, adults, families, and communities.

The Burden

Poor nutrition is contributing to major increases in diet-related obesity and type 2 diabetes, as well as continuing high rates of other chronic diet-related diseases such as cardiovascular diseases, cancers, and other conditions (1). Since the 1970s, Americans' diets have changed significantly. For example, both portion sizes and frequency of snacking have increased, with each linked to greater calorie intake (14, 15). Among US children, substantial increases in daily calories since the 1970s are entirely attributable to increased foods eaten outside from home, mostly from fast food (16). Consistent with prior health messaging to reduce total fat, the percentage of energy from carbohydrates increased from 42% to 48% of calories in men and 45% to 51% in women between 1971 and 2004, primarily due to higher consumption of starches, grains, and caloric beverages (17, 18). Between 1977 and 1994, intake of processed breakfast cereals increased by 60%, intake of pizza by 115%, and intakes of snack foods like crackers, popcorn, pretzels, and corn chips by 200% (19). Between 1965 and 2002, the intake of caloric beverages increased from 12% to 21% of all calories, representing an average increase of 222 calories/d per person (20). This change was due to increased intake of sweetened fruit drinks, alcohol, and especially soda. Over this time, the average portion size of a sugar-sweetened beverage increased by >50% (21).

In more recent years, with growing public awareness of the critical role of nutrition in overall health, some aspects of US diet quality have modestly improved, such as reductions in soda and small increases in whole grains, fruits, and nuts/seeds (22, 23). Nevertheless, intakes of these and other healthful components remain far below dietary guidelines, with 45.6% of adults and 56.1% of children continuing to have poor-quality diets overall, and most of the remainder having intermediate-quality diets, with very few Americans having ideal diets (22, 23). While less well documented by national surveillance data, the levels and types of food processing have substantially changed in the past 50 y. Ultra-processed foods now contribute ~60% of all calories in the US food supply (24). These changes in our nutrition and corresponding diet-related illnesses are associated with rising health care costs, widening diet-related health disparities, and weakened national security and military readiness (25).

Between 1980 and 2018, the percentage of US children with obesity increased from 5.5% to 19.3%, whereas the percentage of adults with obesity increased from 15% to 42.4% (26–30). Nearly 3 in 4 American adults are now either overweight or obese (26, 31, 32). Across all preventable risk factors for disease in the US, poor diet is now the leading cause of poor health, associated with more than half a million deaths per year—or more than 40,000 deaths each month (1). Along with suboptimal diet, adiposity and physical inactivity are shared risk factors for illness and death (33–37). Over the last 20 y, the number of adults with diabetes has more than doubled (38), and today, >100 million Americans—nearly half of all adults—suffer from diabetes or prediabetes (39). Cardiovascular disease afflicts ~122 million Americans and causes ~840,000 deaths each year (40). Many of these diseases disproportionately affect older Americans, and as our nation's demographics shift toward an aging population, the burden of diet-related ailments on society will accelerate (41, 42). In short, more Americans are sick or suffer from major medical conditions than are healthy, and much of this is related to diet-related illness.

Although the general contours of healthy eating patterns have been outlined by important advances in nutrition science, many questions remain unanswered (10). Modern nutrition science is still evolving, with a rapidly growing but still relatively nascent repertoire of research methods, foundational science, and large-scale interventions to investigate and address diet-related diseases. For most of the 20th century, the focus of nutrition research was on isolated vitamins and minerals and their role in clinical nutrient deficiency diseases. This effort led to major accomplishments, such as documenting the role of individual nutrients in diseases such as pellagra (vitamin B-3 deficiency), rickets (vitamin D deficiency), and scurvy (vitamin C deficiency), among others, and then quickly mobilizing innovative technology such as fortification of staple foods, along with well-coordinated policy and programmatic responses, to address these conditions. In comparison, the shift of nutrition science to focus more meaningfully on diet-related chronic diseases, such as heart disease, strokes, cancer, diabetes, obesity, brain health, and autoimmune and inflammatory diseases, is much more recent, largely begun only since the 1980s. In this short period, important knowledge has been gained. Yet, the investment and pace of progress have been insufficient to address the burgeoning rates of diet-related illness and the associated societal and economic consequences.

For example, in detailed reviews of available research by the 2015 Dietary Guidelines Advisory Committee (DGAC), numerous areas were identified as having only moderate, limited, or insufficient (not assignable) scientific evidence for making dietary recommendations (**Supplemental Table 1**). These include, for instance, evidence that healthier dietary patterns favorably influence body weight or obesity in adults (moderate evidence) or children or adolescents (limited); reduce the risk of type 2 diabetes in adults (limited) or children (not assignable); or are associated with lower risk of colorectal (moderate), breast (moderate to limited), lung (limited), or prostate (not assignable) cancer; age-related cognitive impairment, dementia, or Alzheimer disease (limited); depression in adults (limited) or children, adolescents, or postpartum mothers (not assignable); or bone health in adults (limited) or children and adolescents (not assignable). Considering specific individual foods and nutrients, the 2015 DGAC concluded that evidence is only moderate that coffee consumption is associated with reduced risk of type 2 diabetes, cardiovascular disease, or certain cancers and is limited for caffeine intake and lower risk of cognitive decline and Alzheimer disease or increased risk of miscarriage, stillbirth, or low birth weight. The 2015 DGAC found limited evidence to address additives, such as aspartame and risk of cancers or preterm delivery. Evidence was considered moderate for any specific sodium target (e.g., 2400 mg/d) for blood pressure control or risk of cardiovascular outcomes; limited or not assignable for potassium intake and these outcomes; moderate or limited for low-calorie sweeteners and body weight or diabetes; and limited for replacing saturated fat with monounsaturated fat for reducing cardiovascular risk.

The 2015 DGAC identified multiple specific areas of research needs (**Supplemental Table 2**). Examples include the need to conduct research on *1*) the dietary needs and intakes of older adults, whether polypharmacy plays a role in nutritional adequacy, and whether comorbidities, such as poor dentition, musculoskeletal difficulties, arthralgias, vision loss, and other age-related symptoms, affect their ability to establish and maintain proper nutritional status; *2*) nutrition transitions from early childhood to adolescence to identify how and why diets change so rapidly during this period, the driving forces behind these changes, and effective programs to maintain positive nutrition habits established in young children; *3*) the validity, reliability, and reproducibility of new biomarkers of nutritional status; *4*) the effects of fortification strategies and supplement use on consumer behaviors and diets related to calcium, vitamin D, potassium, iron, and fiber; and *5*) design approaches to quantify diets in large population-based studies.

Overall, advances in science have identified numerous new opportunities for research and pressing scientific questions that must be addressed (Figure 2). These topics, discussed further in "The Opportunity" section below, include fundamental questions about foods and diet quality in relation to obesity, insulin resistance, diabetes, cancers, and other conditions; the interactions between diet, physical activity, the microbiome, and immunity and other key health defenses; and the health effects of various forms of food processing, additives, fermentation, and probiotics. Other topics include personalization of nutrition based on each person's background, habits, genes, microbiome, medications, and existing diseases; how hunger and food security influence wellness and key approaches to address this interaction; the intersections of plant and animal breeding and farming practices with nutrition and sustainability; and many other questions. Thus, we have learned much, but the present state of science remains far from offering a sufficient understanding of many crucial facets of food and nutrition fundamental to human health (43–47). Scientific progress is being made, but at the current pace it may take many decades to meaningfully understand and reduce the prevalence and impact of the broad range of diet-related chronic diseases that we face.

The economic costs of nutrition-related diseases are staggering and ever rising. As a share of our economy, total US health care expenditures have nearly tripled since 1970, from 6.9% to 17.9% of Gross Domestic Product (GDP) (48, 49). These increases are harming government budgets, competitiveness of US businesses, workers' wages, and livelihoods of families. Federal health care spending has increased from 5% of the total federal budget in 1970 to 28% in 2018, reducing available funds for other priorities. Similarly, average state government spending on health care has increased from 11.3% of state budgets in 1989 to 28.7% in 2016. For US businesses, health care expenditures have increased 15-fold in 50 y, from $79 billion in 1970 to $1180 billion in 2017 (in constant 2017 dollars) (49). Over this same period, annual per capita health care spending in the US has increased from $1797 to $10,739 (in constant 2017 dollars) (49). And, ~85% of total US health care expenditures are related to management of diet-related chronic diseases (50). For example, the total direct health care and indirect economic costs of cardiovascular diseases are estimated at $316 billion/y; of diabetes, at $327 billion/y; and of all obesity-related conditions, at $1.72 trillion/y (51, 52). These economic costs exceed the annual budget appropriations of most federal departments and agencies, such as (for fiscal year 2020) the budgets of the USDA ($150 billion) (53), DoE ($72 billion) (54), DHS ($51 billion) (55), DoJ ($33 billion) (56), NIH ($42 billion) (57), CDC ($12.7 billion) (58), EPA ($9.5 billion) (59), and FDA ($5.9 billion) (59).

Rising health care expenditures are straining government budgets and private business growth; limiting the ability to support other national, state, and business priorities; contributing to stagnating wages; and bankrupting individuals, families, and small businesses (60, 61). Improving what Americans eat would have a significant impact on reducing diet-related chronic diseases, lowering health care spending, and creating new opportunities for innovation and jobs. Although advancing science has elucidated the broad outlines of healthy eating patterns for making many general dietary and policy recommendations, numerous critical questions remain unanswered, with corresponding scientific debate and public confusion. There is a large and growing appetite among American citizens for credible, rigorous nutritional science information, both for general health but also for treating many specific diseases and ailments. Consumers are inundated with often conflicting information from multiple sources, including the internet, social media, television, marketing, and food and menu labeling, among others, making it difficult to discern trusted information for making informed choices (62). Many American adults remain unaware of foundational federal guidance on nutrition (63, 64), and use the internet or other sources for seeking guidance on what to eat (65).

Poor nutrition also contributes to profound disparities. Prior to COVID-19, food insecurity was a significant challenge for 1 in 8 Americans (66, 67), and is expected to more than double this year. A total of 37 million Americans, including 11 million children, experienced food insecurity in 2018 (68, 69). The dramatic increase in unemployment with COVID-19 is expected to cause food insecurity for an additional 18 million US children, bringing the total to 40% of all US youth (70). Americans are also experiencing ever-widening disparities in diet quality and diet-related chronic diseases by race/ethnicity, education, and income (22, 71–75). While social and economic factors such as lower education, poverty, bias, and reduced opportunities are major contributors to population disparities, they are likewise major barriers to healthy food access and proper nutrition. Poor diets lead to a harsh cycle of lower academic achievement in school, lost productivity at work, increased chronic disease risk, increased out-of-pocket health costs, and poverty for the most vulnerable Americans (76). Addressing these profound diet-related disparities experienced by rural, low-income, and minority populations requires a better understanding of their multilevel and interrelated individual, social, and environmental determinants, and corresponding translational solutions (77–80). As one example, the 2015 DGAC concluded that the current body of evidence on the links between access to retail food outlets and dietary intake was limited and inconsistent (81).

Our national nutrition challenges also diminish military readiness (82). For much of human history, governments have prioritized nutrition to enable a high-performing, able military. During World War II, for example, recognition of the national security threat of undernutrition produced strong federal actions,

such as creation of the first RDAs by President Franklin D Roosevelt in 1941 and of the National School Lunch Program by Congress in 1945 (83). Today, we face very different nutritional challenges: 71% of young people between the ages of 17 and 24 do not qualify for military service, with obesity being the leading medical disqualifier (25). Since 2010, Mission: Readiness—a group of >750 retired US generals, admirals and other top military leaders—has produced several reports documenting the national security threat of childhood obesity (25, 84, 85). In addition, obesity and other diet-related chronic diseases are common among veterans, with more than one-third of veterans seen at the Veterans Health Administration (VHA) being obese (86). Food insecurity is common among veterans seen at the VHA and is associated with suboptimal control of medical conditions (87–89). Both obesity and food insecurity are common and often coexist in active-duty military families (90, 91). Overall, diet-related illnesses are harming the readiness of US military forces and the budgets of the DoD and VA (86, 92, 93). A more robust understanding of nutrition is a top DoD priority to maximize the performance of active-duty forces and their recovery from physical and psychologic injuries (11).

Our food systems are creating challenges to our climate and natural resources with widespread related health consequences (94). Emerging science is advancing the understanding of how nutrition security—access to affordable, sufficient, safe, and nutritious food—is interrelated with challenges and opportunities in use of natural resources (11, 94). While federal nutrition research and coordination is the focus of this white paper, we recognize that nutrition research and agricultural and food systems research are mutually interdependent (95). Ongoing market forces, food production, and consumption patterns, among other factors, are creating not only poor health but large and unsustainable environmental impacts (96). On a global scale, one-quarter of greenhouse gases, 70% of water use, and 90% of tropical deforestation are related to food production. Climate change is warming the planet, contributing to lower crop yields and new economic risks for farmers. These issues and corresponding potential solutions are complex: for example, greenhouse gas emissions have global impact, while water use has more regional impact (97–101). Food waste worsens resource losses, with at least one-third of food produced in the US wasted during post-harvest, and consumer losses (102). The future productivity of US agriculture faces additional growing environmental challenges such as resource scarcity, loss of biodiversity, and soil degradation (96). These sustainability issues have direct relevance for human health, increasing the risk of infectious diseases, respiratory illness, allergies, cardiovascular diseases, food- and waterborne illness, undernutrition, and mental illness (103, 104).

Addressing all of these nutrition-related health, equity, societal, and economic burdens requires advancing science to better understand their biological, individual, social, and environmental drivers. Current scientific knowledge, however, remains insufficient to address the mechanistic determinants and solutions of these complex challenges.

The Current Federal Nutrition Research Landscape

The federal government is the largest supporter of US nutrition research, with a diverse federal nutrition research infrastructure that generates critically important research and surveillance across a range of areas. A new federal research investment and coordination structure must leverage, harmonize, and catalyze—not diminish or replace—these efforts being led across multiple federal departments and agencies.

No current or complete accounting of all federal nutrition research funding is available (12, 105). For this work, we obtained and collated information on the largest departments and agencies focused on nutrition research, and their current estimated spending on nutrition research. These findings are presented in **Table 1**, and summarized further below. The NIH and USDA are by far the 2 largest funders of federal nutrition research. As recently described (12), NIH and USDA negotiated how to share priorities for nutrition science after the 1978 Congressional report on *Nutrition Research Alternatives* (106, 107). The Secretaries of HHS and USDA agreed that NIH would take the lead on research related to the biomedical aspects of nutrition (e.g., diagnosing and treating diseases), while USDA would be responsible for research on healthy diets for the general population. In addition to NIH and USDA, many other departments and agencies conduct or utilize nutrition research (11), as described in further detail below.

In 2003, the Director of the White House Office of Science and Technology Policy (OSTP) estimated that federal investment for food-related (beyond nutrition alone) research and development was $2.5 billion/y (105). A 2015 USDA report estimated that overall federal investment in nutrition research was $1.6 billion/y in 2009, increased from ~$0.8 billion/y in 1985 (in constant 2007 dollars) (**Figure 3**) (108). The increase occurred primarily at NIH, while nutrition funding at USDA declined in real dollars during this period. However, total NIH research funding also doubled between fiscal year 1994 and 2003 (constant dollars) (109). Thus, as a share of overall research expenditures, federal nutrition research spending remained generally flat, despite the dramatic increase in diet-related illnesses such as obesity and diabetes from 1980 to the present (12). A limitation of all such estimates is the reliance on keyword searches of grant projects, which may incorporate funding only peripherally related to nutrition. For example, funding for research identified as related to "obesity" increased nearly 4-fold between 1985 and 2009, and was counted as "nutrition" research (108).

NIH

The NIH is the largest biomedical research agency in the world and largest funder of US nutrition research (110). Important intramural and extramural nutrition research occurs across multiple institutes, centers, and offices, in particular the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK); National Heart, Lung, and Blood Institute (NHLBI); National Cancer Institute (NCI); National Institute of Aging (NIA); Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD); and NIH Office of the Director (110). These institutes focus on diseases or specific subsets of the population, rather than food and nutrition. For example, NIDDK research efforts include diabetes and other endocrine and metabolic diseases; liver disease and other digestive diseases and conditions; nutritional disorders, such as inborn errors of metabolism; obesity; kidney diseases, such as polycystic kidney disease and glomerular disease;

TABLE 1 Current federal nutrition research agencies and departments participating in the US ICHNR[1]

Department or agency (department)	Legislative authorities and appropriations	Description	Estimated annual expenditures on nutrition research,[2] millions
National Institutes of Health (HHS)	Labor, Health and Human Services, and Education, and related agencies	Supports biomedical research, training, and infrastructure in nutrition to improve health and this work is carried out by investigators in research organizations and settings throughout the country, primarily in universities and biomedical research centers	$1900[3]
Agricultural Research Service (USDA)	Agriculture, Rural Development, FDA, and related agencies	Works to advance human nutrition research in a variety of ways, drawing from a number of its national programs, including the Human Nutrition National Program that works to: (1) link agricultural practices and beneficial health outcomes; (2) monitor food composition and nutrient intake of the nation; (3) determine the scientific basis for dietary guidance; (4) prevent obesity and obesity-related diseases; and (5) understand life-stage nutrition and metabolism	$88[4]
National Institute of Food and Agriculture (USDA)	Agriculture, Rural Development, FDA, and related agencies	Invests in and advances agricultural research, education, and extension and through its food, nutrition, and health programs works to strengthen the nation's capacity to address issues related to diet, health, food safety, food security, and food science and technology	$42[5]
Food and Nutrition Service (USDA)	Agriculture, Rural Development, FDA, and related agencies	Conducts research and makes use of the nutrition research sponsored by other federal agencies to help assess and improve the 15 FNS programs and conducts secondary research such as systematic reviews and policy-related research to develop and disseminate the latest edition of the dietary guidelines every five years, including development of USDA Food Patterns, Healthy Eating Index, USDA Food Plans, and communications research	$41[6]
CDC (HHS)	Labor, Health and Human Services, and Education, and related Agencies	Addresses nutritional issues related to population health through surveillance, intramural and extramural research, the translation of research into practice, and program implementation	$9[7]
FDA (HHS)	Agriculture, Rural Development, FDA, and related agencies	Depends on nutrition research to inform its many regulatory and other activities on food labeling, oversight of food additives and constituents of foods, nutrition education activities, and other nutrition-related work; and conducts its own research activities including consumer studies to support nutrition labeling and claims, assessments of constituents of the food supply, development of methods for analyzing food constituents, surveys on health, analyses of dietary intake, monitoring of adverse events from dietary foods and supplements, and cost/benefit analyses of various nutrition regulatory activities	$8[8]
Department of Defense	Defense	Develops, implements, and evaluates effective nutritional strategies to optimize performance before, during, and after training and operations	$5[9]
Agency for International Development	State, Foreign Operations, and related programs	Adopts, adapts, modifies, and increases the information, evidence, practices, and technologies of US institutions in human nutrition to be applicable to USAID target populations in developing countries to: improve food security and nutrient adequacies; increase access to safe water; and reduce infectious diseases, environmental toxins, poor sanitation, and parasitism	$4[10]
Economic Research Service (USDA)	Agriculture, Rural Development, FDA, and related agencies	Conducts and supports studies examining the actions of and interactions among consumers, food industry, and government as they relate to food supply and access; food choice and its impact on diet quality; and federal nutrition assistance, regulation, and other aspects of food policy	NA[11]
Department of Commerce	Commerce, Justice, Science, and related agencies	National Institute of Standards and Technology (NIST) provides food-matrix Standard Reference Materials (SRMs) for the determination of trace element content, including both nutrient elements (minerals) and toxic metal contaminants. National Oceanic and Atmospheric Administration (NOAA) contributes to advancing human nutrition research through its work on seafood	NA[12]
National Aeronautics and Space Administration	Commerce, Justice, Science, and related agencies	Conducts life sciences research in space flight on the International Space Station (ISS) and in ground-based analogs of space flight (e.g., extended bed rest, Antarctic winters, undersea habitats)	NA[13]
Federal Trade Commission	Financial Services	Relevant work and interest primarily focuses on food marketing to children	NA[14]
Environmental Protection Agency	Interior, Environment, and related agencies	Conducts risk assessments regarding dietary exposure of chemicals	NA[15]

(*Continued*)

TABLE 1 (*Continued*)

Department or agency (department)	Legislative authorities and appropriations	Description	Estimated annual expenditures on nutrition research,[2] millions
Health Resources and Services Administration (HHS)	Labor, Health and Human Services, and Education, and related agencies	Provides health care to people who are geographically isolated, economically or medically vulnerable, including people living with HIV/AIDS, women who are pregnant, mothers and their families, and those in need of high-quality primary health care, and supports the training of health professionals, the distribution of providers to areas where they are needed most, and improvements in health care delivery	NA[16]
Total, millions	$2005		

[1] HHS, Department of Health and Human Services; ICHNR, Interagency Committee on Human Nutrition Research; NA, not available; USAID, US Agency for International Development.

[2] There is no annual budget reporting for federal nutrition research and related activities so the footnotes indicate the activities and, where possible, the fiscal year associated with the estimate provided.

[3] The National Institute of Diabetes and Digestive and Kidney Diseases, Office of Nutrition Research. NIH Nutrition Research Task Force. Estimated Nutrition Research Funding, Fiscal Year 2019. Available at https://www.niddk.nih.gov/about-niddk/advisory-coordinating-committees/nih-nutrition-research-task-force (accessed 12 March 2020).

[4] The 2019 President's Budget—Agricultural Research Service. Available at https://www.obpa.usda.gov/18ars2019notes.pdf (accessed 19 March 2020).

[5] Specific Agriculture and Food Research Initiative (AFRI) programs include Foundational and Applied Sciences [anticipated amount available for new grants in this fiscal year 2020 for this request for funding applications (RFAs) is ~ $192.6 million], which includes 6 priority areas including the number 3 area, Food Safety Nutrition and Health, and the Nutrition program area priorities are Diet, Nutrition and the Prevention of Chronic Diseases and Food and Human Health; Sustainable Agricultural Systems (anticipated amount available for new grants in this fiscal year 2020 for this RFA is ~$90 million); and Education and Workforce Development (anticipated amount available for new grants in fiscal year 2019 for this RFA is ~$29.166 million and this fiscal year 2020 has not been determined yet). Selected Higher Education Programs include Distance Education Grants Program for Institutions of Higher Education in Insular Areas (estimated total program funding: $800,000), Higher Education Challenge Grants (estimated total program funding: $4,500,000), and Hispanic-Serving Institutions Education Grants Program (estimated total program funding: $8,800,000). The 2018 Farm Bill increased mandatory commitments to the Gus Schumacher Nutrition Incentive Program up to $250 million over 5 y and estimated total funding for fiscal year 2019 projects was $41 million. In addition, the Community Food Projects Competitive Grant Program estimated total program funding in fiscal year 2019 was ~$4,800,000. Also relevant, the Women and Minorities in Science, Technology, Engineering, and Mathematics Fields Program (WAMS) estimated total program funding in fiscal year 2019 was $400,000. There are other RFAs that solicit nutrition-relevant activities including work with the Expanded Food and Nutrition Education Program (EFNEP) (estimated total program funding in fiscal year 2019 was $68,440,680 to support program implementation by land-grant universities) and partnering with the USDA Food and Nutrition Service (FNS) on Supplemental Nutrition Assistance Program Education (SNAP-Ed) by facilitating communication among federal, state, and local partners and providing programmatic leadership to cooperative extension/land-grant university program implementers for effective nutrition education and obesity-prevention interventions through the land-grant system in conjunction with other implementing agencies and organizations. The USDA National Institute of Food and Agriculture (NIFA) also supports a range of other career development and training programs relevant to human nutrition research.

[6] For fiscal year 2020, overall FNS spending on federal nutrition assistance programs: $97.3 billion; estimated FNS spending on nutrition education and promotion: $1.2 billion [mostly Supplemental Nutrition Assistance Program (SNAP) and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)]; and estimated FNS spending on nutrition assistance-related research and analysis: $34 million [$14 million SNAP, $15 million Child Nutrition (CN), $5 million WIC]. For the Center for Nutrition Policy and Promotion (CNPP), an estimate of ~$6.6 million in fiscal year 2020 for nutrition evidence reviews, committee support, and *Dietary Guidelines for Americans* (DGA)–related educational development. Congress provided CNPP a one-time allocation of $12.3 million in the fiscal year 2019 appropriations bill to complete the 2020–2025 DGA over the next 3 y.

[7] The CDC Division of Nutrition, Physical Activity, and Obesity (DNPAO) funds the Nutrition and Obesity Policy Research Network (NOPREN) at $300,000 each year, which is their only dedicated research project out of the Obesity Branch. The Obesity Branch has 2 full-time employees (FTEs) dedicated to the epidemiology and surveillance of nutrition/obesity (e.g., fruits and vegetables, added sugars, water, food systems, obesity). The CDC's Childhood Obesity Research Demonstration (CORD) Project 3.0 (2019–2024) is focused on childhood obesity weight-management program applied research and nutrition is a component but not considered traditional nutrition research. Five grants were awarded with a total budget of $12.5 million. The Infant Feeding Practices III (IFPS III) (2019–2026) study cost estimate is $3.4 million. The Nutrition Branch has 1 FTE dedicated to the IFPS III. Additional DNPAO funding goes towards other nutrition-relevant surveillance systems. The CDC Division of Population Health School Health Branch addresses nutrition, physical activity, and chronic health conditions in the school setting through research and programmatic activities. The following estimates reflect funds for nutrition-related research activities: *1*) Contribution to the Youth Risk Behavior Surveillance System (YRBSS) and School Health Profiles, which is administrated by the CDC's National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention Division of Adolescent and School Health: $18,500 per year (this is the portion for nutrition topics). Also, 1.5 FTEs work on nutrition research including descriptive and analytic projects, research synthesis, and research translation. The School Health Branch also supports program evaluation relevant to nutrition estimated at 0.5 FTE and $100,000 per year in 1801 evaluation contract. There are other activities within the CDC's National Center for Chronic Disease Prevention and Health Promotion that are relevant to nutrition and these activities likely account for a 5% estimate of non-DNPAO Divisions' budgets (see the US Department of Health and Human Services, CDC National Center for Chronic Disease Prevention and Health Promotion. Available at https://www.cdc.gov/chronicdisease/programs-impact/budget/index.htm (accessed 27 April 2020). The total costs to conduct the NHANES in fiscal year 2019 was ~$40 million. This does not include staff salaries or in-kind contributions for work such as laboratory processing or dietary data coding provided by other parts of the CDC or other agencies such as USDA. This also does not include nutrition-related support for the NHANES from outside the CDC. The nutrition-related NHANES activities attributable costs was ~$8 million for fiscal year 2019.

[8] The US Government Accountability Office (GAO). Report to Congressional Requesters: Food Safety and Nutrition. FDA Can Build on Existing Efforts to Measure Progress and Implement Key Activities. GAO-18–174. January 2018. Available at https://www.gao.gov/assets/690/689796.pdf (accessed 26 February 2020).

[9] The largest resource for nutrition research is the Army, which received ~$3.3 million in fiscal year 2020 for its intramural nutrition research program. The Army nutrition research program also seeks extramural support, which varies from year to year but in fiscal year 2020 is estimated to receive $1.4 million. The Uniformed Services University of Health Sciences is estimated to receive $750,000 per year for the next 3 y. Other services, including the Air Force and Navy, conduct nutrition research, although budgets vary and may depend upon extramural funding sources.

[10] The US Agency for International Development (USAID) Report to Congress on Health-Related Research and Development for Fiscal Year 2018. Available at https://www.usaid.gov/open/reports-congress (accessed 27 February 2020).

[11] USDA Economic Research Service (ERS) fiscal year 2019 budget was $87 million, which covered research led by 3 research divisions: market and trade economics, resource and rural economics, and food economics. The ERS does not have a more specific number for food, food security, and nutrition-relevant research. The Research Innovation and Development Grants in Economics (RIDGE) program was supported by USDA ERS and FNS; it awarded 8 grants in 2019 and will hold a conference to present findings from those awards in 2020 but has no further funding at this point. The RIDGE program has funded >285 products at >100 educational and research institutions during 1998–2019. USDA ERS and FNS have co-sponsored the National Household Food Acquisition and Purchase Survey (FoodAPS-1); research grants for analysis of FoodAPS-1, and methodological research to develop FoodAPS-2, as well as a number of data development activities. Between 2013 and 2018, USDA FNS funded ~50 cooperative research agreements and grants between the ERS researchers, university-based centers, and university-based researchers, tallying >$3 million provided through the ERS. These agreements have covered wide ranging topics including food security, SNAP, WIC, School Meal Programs, promotion of healthier eating, and the food retail environment.

[12] There is a specific internal budget for the production of Standard Reference Materials (SRMs), which includes but is not limited to the National Institute of Standards and Technology's (NIST's) food matrix items but there is not an exact estimate at this time for other nutrition research–relevant activities across the NIST. Relevant program descriptions indicating staff support and activities are available on the NIST website (see NIST. Measurements and Standards to Support Nutrition Labeling. Available at https://www.nist.gov/programs-projects/measurements-and-standards-support-nutrition-labeling; accessed 27 April 2020). There is no current budget estimate for the National Oceanic and Atmospheric Administration's (NOAA's) nutrition research relevant activities while current staff are actively engaged in this area.

[13] The National Aeronautics and Space Administration's (NASA's) complete food capability roadmap is still under construction, and unfortunately it is not at liberty to share these budget details, but this is a high priority area.

[14] The Federal Trade Commission (FTC) has not engaged in any research related to nutrition in recent years. Since about 2010, Congress prohibited the FTC from completing the study they were conducting with FDA, CDC, and USDA on nutrition standards for food marketing to children.

[15] There is no specific nutrition research budget as this work is mainly in-house analyses utilizing the NHANES data. Other groups within the Environmental Protection Agency such as the Office of Research and Development and the Office of Air and Radiation also rely on the NHANES, but these data are freely available and NHANES is not contracted with the CDC to collect.

[16] Nutrition is generally addressed in the context of larger initiatives, so it is not possible for the Health Resources and Services Administration (HRSA) to break out an accurate funding estimate.

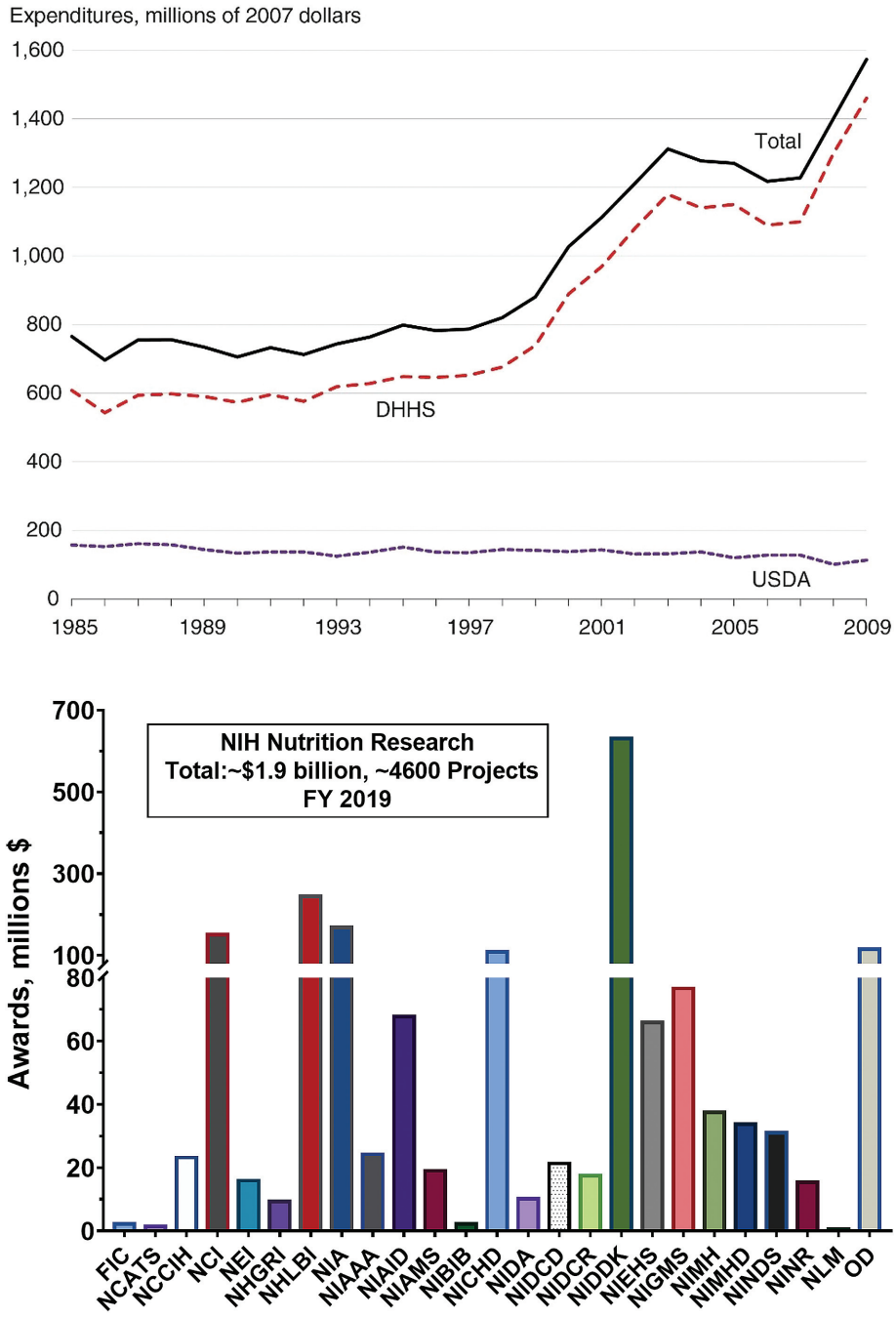

FIGURE 3 Estimated overall federal expenditures for nutrition research, 1985–2009 (top panel) (108); and within NIH for fiscal year 2019 (bottom panel) (110). The top panel is based on information provided by the DHHS (NIH, FDA, CDC), USDA, VA, USAID, DoD, DoC, NSF, and NASA using data from the NIH Human Nutrition Research Information Management system and the Biomedical Research and Development Price Index. The bottom panel is based on data from all NIH institutes, centers, and offices (*x* axis) that provided funding for nutrition research in fiscal year 2019, listed in alphabetical order. DHHS, Department of Health and Human Services; DoC, Department of Commerce; DoD, Department of Defense; FIC, Fogarty International Center; FY, fiscal year; NASA, National Aeronautics and Space Administration; NCATS, National Center for Advancing Translational Sciences; NCCIH, National Center for Complementary and Integrative Health; NCI, National Cancer Institute; NEI, National Eye Institute; NHGRI, National Human Genome Research Institute; NHLBI, National Heart, Lung, and Blood Institute; NIA, National Institute of Aging; NIAAA, National Institute on Alcohol Abuse and Alcoholism; NIAID, National Institute of Allergy and Infectious Diseases; NIAMS, National Institute of Arthritis and Musculoskeletal and Skin Diseases; NIBIB, National Institute of Biomedical Imaging and Bioengineering; NICHD, Eunice Kennedy Shriver National Institute of Child Health and Human Development; NIDA, National Institute on Drug Abuse; NIDCD, National Institute on Deafness and Other Communication Disorders; NIDDK, National Institute of Diabetes and Digestive and Kidney Diseases; NIEHS, National Institute of Environmental Health Sciences; NIGMS, National Institute of General Medical Sciences; NIMH, National Institute of Mental Health; NIMHD, National Institute on Minority Health and Health Disparities; NINDS, National Institute of Neurological Disorders and Stroke; NINR, National Institute of Nursing Research; NLM, National Library of Medicine; NSF, National Science Foundation; OD, Office of the Director; USAID, US Agency for International Development; VA, Department of Veterans Affairs. Reprinted with permission from the USDA Economic Research Service and NIDDK Office of Nutrition Research.

urologic diseases and conditions; and blood diseases (111). The NHLBI aims to promote the prevention and treatment of heart, lung, and blood diseases, which includes strategic priorities around dietary assessment methodologies that combine objective dietary measures and biomarkers to help identify dietary patterns and food constituents that contribute to weight maintenance and to inform intervention strategies to lower cardiometabolic risks (112). The NCI leads, conducts, and supports cancer research to advance scientific knowledge and help all people live longer, healthier lives, which includes efforts to advance dietary assessment methodology (113). The NIA leads a broad scientific effort to understand the nature of aging and to extend the healthy, active years of life, including building the understanding of the roles of nutrition, obesity, sleep, and metabolic status (114). The NICHD aims to investigate human development through the entire life process, including the role of nutrition (115).

Within the NIH Office of the Director, as one example of several offices relevant to nutrition, the NIH Office of Dietary Supplements works to promote the scientific study of the benefits of dietary supplements in maintaining health and preventing chronic disease and other health-related conditions (116).

For fiscal year 2019, total NIH expenditures for nutrition research were estimated at $1.9 billion, supporting a total of ~4600 active projects across at least 25 of the 27 NIH institutes, centers, and offices (Figure 3) (110). NIH's investment in nutrition research has been estimated at 5% of total funding, a percentage that "has remained largely flat for at least three decades, and pales in comparison to many other areas of research" (**Figure 4**) (12). A separate analysis of NIH-supported research grants and cooperative research projects between 2012 and 2017 found that only 16.7% of projects and 22.6% of funding supported investigations focused on primary prevention or secondary prevention (treatment) of disease in humans (117). And, among this subset, only 7.8% included a focus on diet (118). Thus, this careful analysis suggests that only 1.3% of all research projects supported by NIH in recent years focused on the role of diet in the prevention or treatment of disease in humans (119). Another recent NIH analysis evaluated the leading risk factors and causes of death and disability in the US, compared with NIH funding on these factors, and concluded that large mismatches exist between the top causes of poor health versus research funding to address them, with the largest gap being for nutrition (120).

Over the years, NIH has aimed to coordinate the diverse nutrition science research being conducted or supported across the agency through a range of initiatives, including recent efforts to help accelerate the science of obesity research (**Supplemental Table 3**) (121). In 1975, the NIH Nutrition Coordinating Committee (NCC) was established within the NIH Office of the Director to improve nutrition research coordination and communications within NIH and across the federal government (122). In 1993, NCC was moved from the Office of the Director, the highest level of leadership within NIH, into one of the institutes, NIDDK, where NIH Division of Nutrition Research Coordination (DNRC) was established (123). The DNRC comprised ~10 full-time employees, more than half with PhDs. In 2015, DNRC was disbanded and transitioned from an NIDDK Division into an NIDDK Office, the Office of Nutrition Research (ONR) (123) [within NIDDK, a lower organizational stature and size than a division (124)]. The ONR now comprises 2 PhD-level scientists and 3 other staffers (125). The ONR hosts the renamed and slightly restructured NIH Nutrition Research Coordinating Committee (NRCC) (122). In 2016, one of the main tasks of ONR was to develop the first overall NIH strategic plan to expand mission-specific nutrition research (123). The NIH Nutrition Research Task Force was established later in 2016 to guide the development and implementation of the first NIH-wide strategic plan for nutrition research for the next 10 y (126). A draft plan was released for public comment in the Fall of 2018—the original date the final plan was to be made public (127, 128).

The final 2020–2030 Strategic Plan for NIH Nutrition Research was released in May 2020. Including several themes from the 2016 National Nutrition Research Roadmap (11) (see "ICHNR" section below), this first-of-its-kind NIH plan is organized around 4 strategic goals (129):

1) Spur discovery and innovation through foundational research: What do we eat and how does it affect us?
2) Investigate the role of dietary patterns and behaviors in optimal health: What and when should we eat?
3) Define the role of nutrition across the lifespan: How does what we eat promote health across the lifespan?
4) Reduce the burden of disease in clinical settings: How can we improve the use of food as medicine?

The NIH plan includes 5 cross-cutting areas: minority health and health disparities; health of women; rigor and reproducibility; data science, systems science, and artificial intelligence; and training the nutrition scientific workforce (130). Examples of priority objectives in the 4 strategic areas include to investigate bioinformatic gaps in nutrition-related genes and pathways, diet-host-microbiome interrelationships, new tools for microbiome and precision nutrition research, mechanisms of interindividual variability in responses to food-based dietary patterns, influence of diet on infant developmental and health outcomes, the role of nutrition in older adults to promote healthy aging, and interactions between drugs, diseases, and nutrition to improve clinical care and outcomes, among others. How new NIH funding streams, leadership, coordination structures, or other implementation strategies may help achieve these important goals were not detailed. Also in May 2020, the trans-NIH Precision Nutrition Working Group of the NIH Common Fund, in collaboration with the NIH Nutrition Research Task Force, published a request for information on the challenges and opportunities in precision nutrition research (130). The NIH Common Fund is planning a potential program in Precision Nutrition for fiscal year 2021 (131), potentially similar to other Common Fund–supported endeavors such as the *All of US* Research Program and the NIH Human Microbiome Project (see "Options" section below).

USDA

Starting in 1895, Dr. Wilbur Atwater's pioneering work at USDA laid much of the groundwork for modern nutrition science in the US as well as many current USDA nutrition research programs (132). The USDA is the second largest federal funder of nutrition-relevant research, with activities across multiple agencies (Table 1) (133). The Farm Bill requires the Secretary of USDA to establish and support food and human nutrition research

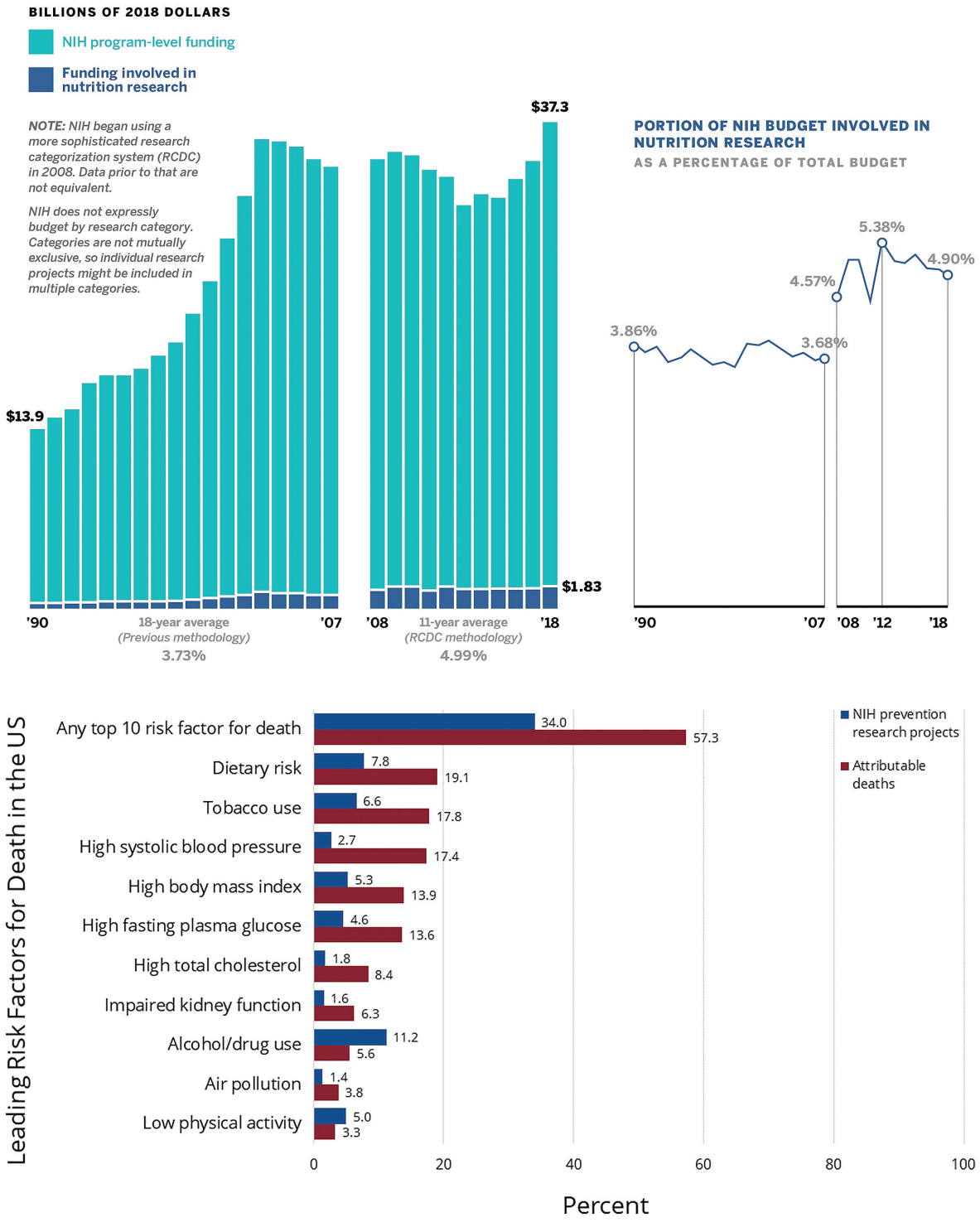

FIGURE 4 Trends in NIH investments in total nutrition research based on data from the NIH, Hathi Trust, and the Government Publishing Office (12) (top panel) and the 2020 NIH analysis of the percentage of NIH's prevention research projects focused on leading risk factors for death in the US compared with the percentage of deaths caused by these leading risk factors in the US (120) (bottom panel). Top panel adapted from POLITICO Pro Datapoint (12), with graphic design support courtesy of Ink&Pixel Agency.

as a distinct mission of the Department, including coordinating nutrition research within the Department and with agencies across the federal government, as well as using formalized mechanisms for external input. The USDA also has a major focus on implementing federal nutrition programs to segments of the public, which constitute the majority of USDA's budget. The importance of the nutrition assistance and associated nutrition education programs for improving food security and health

and preventing disease in low-income populations creates a particularly important need to integrate and connect nutrition research from within and outside USDA to inform and guide policy development for these programs.

The agencies in USDA's Research, Education, and Economics (REE) mission area work to integrate research, analysis, and education to create a safe, sustainable, competitive US food and agricultural system and strong, healthy communities, families, and youth (134). REE science agencies include the ARS, NIFA, ERS, and National Agricultural Statistics Service (135). The ARS' Human Nutrition Program emphasizes food-based approaches for health, including a core network of 6 internationally recognized Human Nutrition Research Centers with scientists, equipment, and facilities for long-term, multidisciplinary, translational research (136, 137). NIFA supports postsecondary education at 113 land-grant colleges and universities (Public Law 37–130), as well as 21 historically black colleges and universities (Public Law 51–841) and 37 tribal colleges and universities (Public Law 89–329) (138–141). While federal funding for these schools initially focused on agricultural research and extension, over time these schools have increasingly focused on human nutrition and food research and extension nutrition education, although the recent growth in research is largely through additional competitive grant mechanisms rather than direct NIFA support to the Agricultural Experiment Station. NIFA further supports extramural nutrition research, often with a focus on integrating agricultural considerations with promotion of health and decreasing health disparities; this work includes funding projects aiming to identify environmental and behavioral factors that act as barriers to consumption of a high-quality diet, while identifying factors that promote healthy eating behaviors (e.g., increasing home access and availability of fruits and vegetables) (142). The ERS' food and nutrition research aims to study demographic, social, economic, and informational determinants of adequacy and healthfulness of the American diet, related health outcomes, and corresponding health care expenditures (11, 143). This research includes examining interactions among consumers, food industry, and government as they relate to the food supply, markets, and access; food choice and its impact on diet quality; federal regulations and other aspects of food policy; and the USDA's nutrition assistance programs in meeting public policy and nutrition goals.

The Food and Nutrition Service (FNS) is the only agency of the Food, Nutrition, and Consumer Services mission area. The FNS administers 15 domestic nutrition assistance programs, conducts some limited research, and makes use of nutrition research sponsored by other federal agencies to help assess and improve these programs. And, as discussed in the cross-governmental section below, the USDA FNS Center for Nutrition Policy and Promotion (CNPP) conducts the evidence analysis for the DGAs, including nutrition evidence systematic reviews, data analysis, and food pattern modeling, and develops the corresponding consumer-facing education tools (e.g., MyPlate) (144, 145).

USDA investments in research and statistics, including nutrition, have fallen below 1980s levels in constant dollars (Figure 3) (12, 146). Indeed, as a percentage of GDP, public investment in agrifood (agriculture and food combined) research and development (4.2%) and particularly food research and development (1%) was lower in 2018 than pharmaceutical research and development (4.9%) (147). The US fell behind China in public agricultural research in 2009, and now only invests half the amount as China (148). US public sector funding for agricultural research and development is also lower than India, Western Europe, and the Asia-Pacific region including Canada, using constant 2011 purchasing-power parity (148). Yet, growth in productivity in the farm sector has come almost exclusively from science-based innovations (146). Declines in US public funding for food and agriculture research and development "risks national competitiveness, long-term cutting-edge scientific discovery, and the next generation talent pipeline" (147). Specific to nutrition, as one example, the ARS budget for human nutrition research and monitoring, including funding for 6 important extramural and intramural Human Nutrition Centers nationally, has been flat since 1980 in constant dollars (**Figure 5**) (132). In addition, 2 USDA research and statistical agencies that include nutrition research—ERS and NIFA—were relocated to Kansas City, Missouri, at the start of fiscal year 2020 and lost 50% (ERS) and 71% (NIFA) of their workforce (149). A recent Congressional Research Service analysis reported the leadership positions at NIFA and ERS have been staffed primarily by acting officials since the relocation and indicated that Congress may be interested in how NIFA and ERS are meeting their responsibilities with reduced workforces and as new staff are potentially hired (150). These trends demonstrate declining investments in science to advance US food and agriculture to increase health, sustain our natural resources, and stimulate rural economic development.

The USDA has aimed to coordinate nutrition research within and outside the department in many different ways (**Supplemental Table 4**) (132). The Food Security Act of 1985 (Public Law 99–198) required the Secretary of Agriculture to submit to Congress "a comprehensive plan for implementing a national nutrition research program, including recommendations relating to research directions, educational activities, and funding levels necessary to carry out such a plan." This plan was submitted to Congress in 1986, but no new legislative mandates or change in mission resulted from this report (132, 151, 152). In 1993, USDA revised its human nutrition program coordination structure and developed a Human Nutrition Policy Committee that reported to the Secretary's Policy Coordination Council and a USDA Human Nutrition Coordinating Committee (HNCC) that reported to the Policy Committee. The Human Nutrition Policy Committee has not been active since the late 1990s. HNCC is chaired by an ARS representative and vice-chaired by an FNS representative and includes members from a variety of USDA agencies with additional liaisons from HHS. Over the last 2 decades, HNCC has generally met quarterly. Each March, HNCC coordinates National Nutrition Month activities at USDA and functions as the steering committee for the website Nutrition.gov (153). USDA Office of the Chief Scientist (OCS) was established by Congress in 2008 (Public Law 110–234) "to provide strategic coordination of the science that informs USDA's and the federal government's decisions, policies, and regulations that impact all aspects of US food and agriculture and related landscapes and communities." (154) The OCS advises USDA's Chief Scientist and the Secretary of Agriculture in multiple areas, including the following: Agricultural Systems and Technology; Animal Health and Production, and Animal Products; Plant Health and Production, and Plant Products; Renewable Energy, Natural Resources, and Environment; Food Safety, Nutrition, and Health; and Agricultural Economics and Rural Communities. By

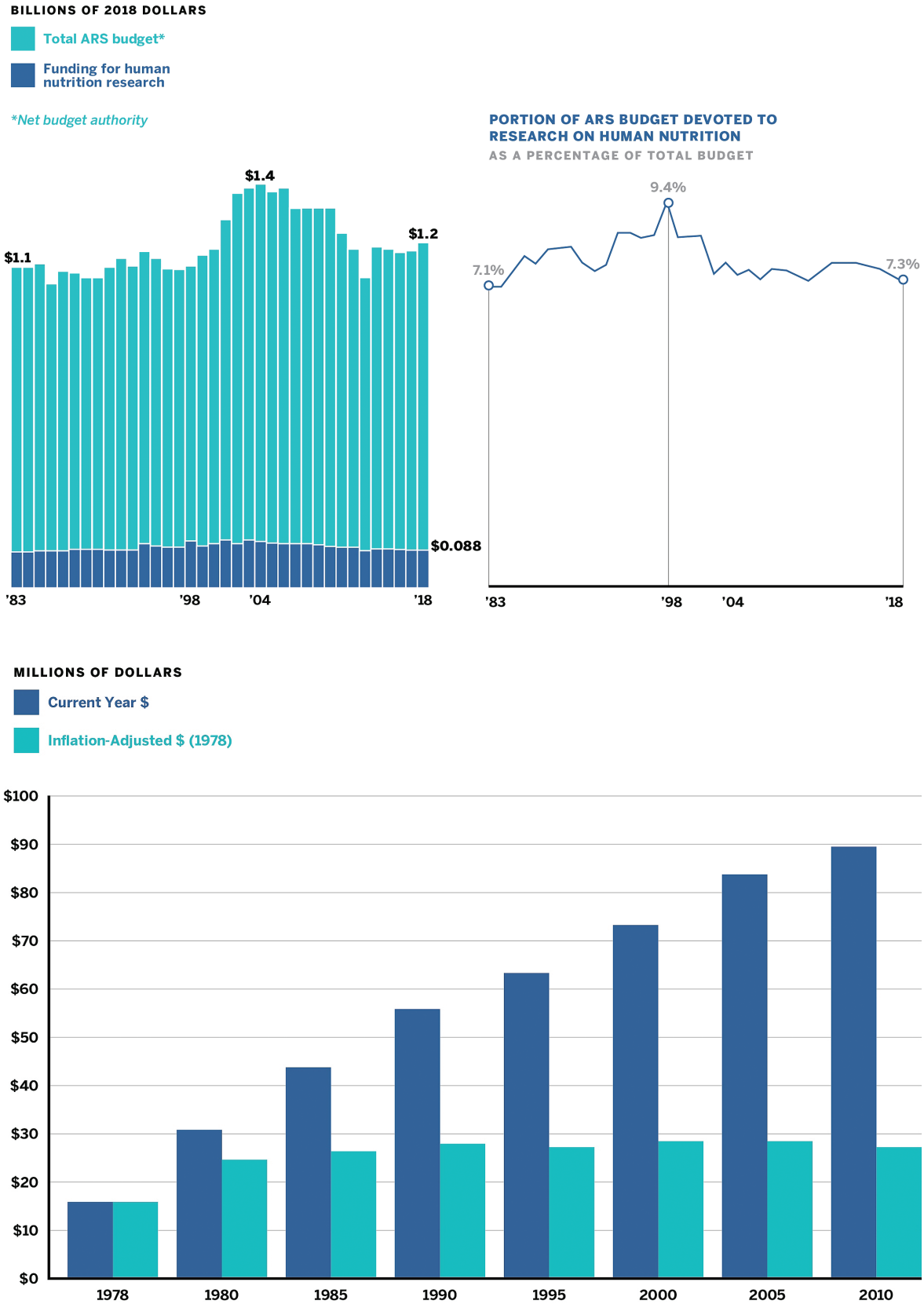

FIGURE 5 Trends in USDA ARS investments for total nutrition research based on data from the USDA, Hathi Trust, and the Government Publishing Office (12) (top panel) and for human nutrition research and monitoring for fiscal years 1978–2010 based on data from the USDA (132) (bottom panel). In the bottom panel, shaded bars represent absolute yearly funding (millions of dollars) and open bars represent funding adjusted to 1978 dollars (https://data.bls.gov/cgi-bin/cpicalc.pl). ARS, Agricultural Research Service; FY, fiscal year. Top panel adapted from POLITICO Pro Datapoint (12), with graphic design support courtesy of Ink&Pixel Agency.

statute, OCS is primarily staffed by detailed staff from other departments and agencies across the government for potentially up to 3 years. In 2017, OCS hosted the first-of-its-kind USDA Intra-Departmental Nutrition Workshop Series and identified major gaps and needs to strengthen coordination of USDA nutrition research. These gaps and needs included the following: assessing existing and potential new means of coordination and collaboration; developing new interdepartmental working groups and interest groups; identifying new and improved ways to enhance coordination with USDA food safety efforts; better utilizing the HNCC; and hosting overviews of USDA nutrition relevant databases and related data science trainings and resources. The chair of this workshop series was detailed to OCS for 1 y and completed the detail a few months after this workshop. A 2019 GAO report noted there are currently no plans for another intradepartmental meeting on nutrition (155).

In 2020, USDA put forth a new Science Blueprint for the next 5 y to help promote synergy across the department for prioritized objectives and strategies (156). This Blueprint includes specific objectives in nutrition and health promotion, such as to develop and update the current evidence base to promote proper macro- and micronutrient intake among critical age groups or life stages, such as women who are pregnant or lactating, infants, children, adolescents, working-age adults, tribal members, and seniors; provide guidance and incentives to promote healthier eating patterns so that the US can reduce incidence of, and morbidity from, obesity and diet-related chronic diseases; promote food systems that reduce the prevalence and severity of food insecurity; and expand understanding about the impacts of USDA nutrition assistance programs on human health, communities, and the economy. The USDA Science Blueprint has objectives related to infrastructure, innovation, and well-being: to develop and evaluate methods to increase access to low-cost and nutritious food as well as sustain efficient agriculture and bioeconomy systems in rural communities; and to evaluate alternative systems that may improve the quality, resiliency, and sustainability of food, fiber, forest, and fuel supplies. The USDA also set forth objectives to work toward being a "beacon for science": to encourage a global conversation and facilitate such discussion within decision-making bodies about literacy in agriculture, food, forestry, health, and science; advocate globally for the development of science-based, international and domestic standards, regulatory approaches, and policies, including those guiding the development of new and emerging technologies; develop an effective and diverse US agriculture workforce that contributes to safer, healthier, vibrant, sustainable, and innovative communities; enhance the capacities of USDA and other institutions in workforce development, with attention towards developing scientists and practitioners familiar with developing technologies and innovative practices; and develop and expand degree, certificate, curriculum, and youth programs that integrate science, technology, engineering, and mathematics (STEM) into instruction, considering real-world challenges relevant to agriculture and food science. How new federal funding streams, leadership, or coordination structures may help achieve these laudable goals were not addressed in the report. On 20 February 2020, the Secretary of Agriculture put forth a new Agriculture Innovation Agenda, a department-wide initiative to align resources, programs, and research to position American agriculture to better meet future global demands. Benchmarks of success included reducing US food loss and waste by 50% by the year 2030 and reducing US nutrient loss in water by 30% by 2050 (157).

Nutrition research in other federal departments and agencies

In addition to NIH and USDA, many other departments and agencies conduct or utilize nutrition research (Table 1). This section highlights summaries provided by 8 departments and agencies in the Topics of Interest section of the 2016 National Nutrition Research Roadmap, as well as any major developments since then (11). The Roadmap explained each of the participating ICHNR department and agency's missions, roles and responsibilities, and mechanisms for supporting and/or using nutrition research; many include histories and contemporary overviews of research needs and interests.

The DoD, for example, focuses on nutrition's role in human performance and resilience. At the US Army Natick Soldier Systems Center, DoD supports scientists and technologists conducting innovative research to develop foods and combat rations that are nutritious, palatable, and nonperishable (158). In Natick, the Combat Feeding Directorate, a part of the Combat Capabilities Development Command of the US Army Futures Command, provides DoD with a joint-service program responsible for research, development, testing, and integration and engineering for materiel solutions such as combat rations, food service equipment technology, and combat feeding systems. The Military Nutrition Division (MND) of the US Army Research Institute of Environmental Medicine, a part of the US Army Medical Research and Materiel Development Command, also of the US Army Futures Command is co-located in Natick with the Combat Feeding Directorate. The MND conducts research that provides the biomedical science basis for warfighter nutritional requirements utilized for the development of rations, menus, policies and programs that enable warfighter health and performance, evaluates warfighter nutritional status, and examines interactions between nutrition, health, performance and the operational environment. The Consortium for Health and Military Performance (CHAMP) at the Uniformed Services University of the Health Sciences (DoD's health sciences university) conducts various nutrition-related research on the nutrition environment (Go For Green and the Military Nutrition Environment Assessment Tool) and tests strategies to mitigate the consequences of environmental and/or physiological stressors and sustain physical and cognitive performance. CHAMP is also extensively involved in dietary supplement research—from beneficial ingredients to those that could compromise force readiness. Both MND and CHAMP collaborate on projects whenever possible to maximize efficiencies and effectiveness.

NASA conducts nutrition research to understand the dietary requirements of space travelers and the role of nutrition in human adaptation to microgravity, each critical to crew safety and mission success. The CDC addresses population nutrition through surveillance, intramural and extramural research, and translation of research into program implementation. The FDA is responsible for protecting the public health by ensuring the safety of our nation's food supply, among other activities (159). The FDA works to foster an environment to promote healthy and safe food choices through several actions. This includes providing

and supporting accurate and useful nutrition information and education to customers, monitoring and assessing emerging nutrition science and changes in the composition of foods in the marketplace in relation to the health status of Americans, and encouraging and facilitating new products and product reformulation to promote a healthier food supply. To achieve this mission, FDA depends heavily on federal nutrition research from other departments and agencies and also conducts its own research activities, such as consumer studies to support nutrition labeling and claims, assessments of constituents of the food supply, development of methods for analyzing food constituents, surveys on health, analyses of dietary intake, monitoring of adverse events from dietary foods and supplements, and cost–benefit analyses of various nutrition regulatory activities. The VA is home to the largest integrated health care system in the US. Known as the VHA, this system includes ∼150 medical centers and 1400 community-based outpatient clinics, community living centers, Vet Centers, and domiciles. The VHA Office of Research and Development supports a range of projects that relate to nutrition including The Million Veteran Program, which aims to build one of the largest databases of genetic, military exposure, lifestyle, and health information. USAID adopts, adapts, modifies, and increases the information, evidence, practices, and technologies of US institutions in human nutrition to be applicable to USAID target populations in developing countries as a key plank of US diplomacy and security. Demonstrating its increased prioritization of nutrition, USAID recently hired its first Chief Nutritionist, who aims to galvanize support for the December 2020 Nutrition for Growth Summit and secure commitments from partner countries, private sectors, and nongovernmental organizations to accelerate progress on improving nutrition worldwide (160).

There are a variety of other federal departments and agencies that are not a member of ICHNR that engage with and leverage nutrition research, such as, but not limited to, HHS Centers for Medicare and Medicaid Services (CMS), HHS Center for Medicare and Medicaid Innovation (CMMI), HHS Office of the Surgeon General, Federal Emergency Management Agency (FEMA), and Departments of Veterans Affairs, Education, Energy, Transportation, Labor, Homeland Security, Housing and Urban Development, Interior, and Justice.

Current Efforts for Cross-Governmental Nutrition Research Coordination

Given the diverse investments in nutrition research across separate federal departments and agencies, several initiatives have aimed to better coordinate these efforts. Major initiatives are summarized below.

ICHNR

In 1977, Congress recognized the need and called for improved coordination of human nutrition research (Public Law 95–113) (**Supplemental Text 1**). Congress further requested its Office of Technology Assessment to review existing federal human nutrition research, with findings published in the 1978 report *Nutrition Research Alternatives* (106). This report found that federal nutrition research programs had failed to deal with the changing health problems of the American people. In response, Congress chartered the Joint Subcommittee on Human Nutrition Research (JSHNR), under the aegis of OSTP, who, in a 1980 report, recommended an improved planning system to coordinate federal nutrition research (161). In 1982, the GAO was also asked to review federal nutrition research and concluded that the government had no overall federal nutrition plan with specific goals or unified and coordinated strategies, while acknowledging the ongoing work of USDA, HHS, and OSTP to develop a coordinated planning system (162).

In 1983, JSHNR completed its review and recommendations, leading to the formation of the ICHNR. The aim of ICHNR was to fill the identified gaps of insufficient planning and coordination and achieve "the pursuit of new knowledge to improve the understanding of nutrition as it relates to human health and disease … in 5 major areas: biomedical and behavioral sciences, food sciences, nutrition monitoring and surveillance, nutrition education, and impact on nutrition of intervention programs and socioeconomic factors" (161). ICHNR co-chairs are the HHS Assistant Secretary for Health and USDA Undersecretary for Research, Education, and Economics (who is also USDA Chief Scientist)—positions filled by Presidential appointment with Senate confirmation. ICHNR includes representatives from multiple federal departments and agencies (Table 1).

After some early collaborative successes, ICHNR had a ≥10-y hiatus (**Supplemental Table 5**). Reassembled in 2013, ICHNR recognized the need for a new effort to coordinate federal nutrition research. This resulted in a new strategic plan, the National Nutrition Research Roadmap 2016–2021: Advancing Nutrition Research to Improve and Sustain Health (11). The Roadmap was framed around 3 questions:

1) How can we better understand and define eating patterns to improve and sustain health?
2) What can be done to help people choose healthy eating patterns?
3) How can we develop and engage innovative methods and systems to accelerate discoveries in human nutrition?

Across these 3 questions, 11 topical areas were identified based on population impact, feasibility given current technological capacities, and emerging scientific opportunities (**Supplemental Figure 1**) within which 120 short- and long-term research and resource initiatives were defined. Each of the participating ICHNR departments or agencies also briefly described their own interests in the Roadmap's 11 topical areas (**Supplemental Figure 2**). The Roadmap also identified gaps in the US nutrition research workforce and put forth recommendations for developing a diverse, interdisciplinary workforce able to advance nutritional sciences research.

Notably, the Roadmap did not include any data, findings, or recommendations on current or new nutrition research investment levels, leadership, or structures (11). Thus, the Roadmap lacked any prioritization between the 120 identified initiatives, due to variable and nonharmonized funding criteria, priorities, and capacities across federal, nonprofit, and private-sector research agencies in the US and globally. This may be why a 2017 analysis found only early signs of implementation of the Roadmap among ICHNR member departments and agencies (163). ICHNR recognized that further engagement with the extramural scientific community and leveraging existing or new

public–private partnerships would be important to achieving the Roadmap's goals (163). Currently, ICHNR has a narrower focus, meeting about twice per year to discuss the DGAs, DRIs, and a potential new federal database of nutrition research projects. There are few other indicators of current use or monitoring of the Roadmap's aims or progress (164). Although ICHNR is the current major entity charged with improving coordination among federal departments and agencies engaged in nutrition research (164), several structural challenges have limited its impact. These include lack of any strong or consistent connection to the White House, no specific budget appropriations, no mechanism for reporting to Congress, and absence of any well-supported infrastructure for external advisory input on cross-governmental strategies for nutrition research.

National food and nutrition monitoring and surveillance

National monitoring and surveillance are integral to nutrition research and translation. Several CDC and other federal collaborations (**Supplemental Table 6**) and USDA efforts (Supplemental Table 4) focus on food and nutrition monitoring and surveillance surveys and related research (**Supplemental Table 7**). These federal efforts began with an international focus to lend expertise and capacity to developing nations to help them develop nutritional assessment and data-informed food and nutrition policy and programmatic responses, such as food fortification and research and training in nutritional sciences (165). For example, in 1955, the Interdepartmental Committee on Nutrition for National Defense was formed after malnutrition was identified to be common among the troops of Korea and China (166, 167). After initial emphasis on surveillance of nutrition programs among military personnel, this Committee expanded focus to civilians in countries of "special interest," ultimately conducting surveys in 33 developing countries (165). In 1967, this international surveillance program was reorganized in response to Congressional amendments to focus on domestic hunger and malnutrition. In 1968, the Ten State Nutrition Survey identified severe malnutrition in several low-income US states (168), stimulating Congressional hearings regarding hunger and the formation of the US Senate Select Committee on Nutrition and Related Needs. In 1969, President Nixon commissioned the first and still only White House Conference on Food, Nutrition, and Health, which put numerous concrete recommendations that led to expansion and standardization of school lunch and Food Stamps, and the creation of school breakfast and the USDA Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) (13, 169).

In 1990, Congress (Public Law 101–445) created the National Nutrition Monitoring and Related Research Program (NNMRRP), with aims to produce a comprehensive, coordinated program for nutrition monitoring and related research to improve assessment of the US population's health and nutrition. Congress required this program to achieve coordination of federal monitoring efforts within 10 y, guided by a new Interagency Board for Nutrition Monitoring and Related Research (IBNMRR) and a 9-member National Nutrition Monitoring Advisory Council. The IBNMRR convened between 1991 and 2002, co-chaired by HHS Assistant Secretary for Health and USDA Undersecretary for Research, Education, and Economics, and was charged with designing and implementing a 10-y comprehensive plan for planning and coordinating the activities of 22 federal agencies that conduct nutrition monitoring and surveillance or related research or are major users of nutrition monitoring data (170). The IBNMRR published its 10-y plan in 1993, and summarized ongoing federal nutrition monitoring in its *Directory of Federal and State Nutrition Monitoring Activities* in 1989, 1992, 1998, and 2000 (171, 172). The impact of this plan is difficult to quantify, although in its first 5 y, 97 proposed and final regulations citing NNMRRP data were published in the Federal Register (173). When this program ended in 2002, federal nutrition monitoring efforts returned to being decentralized, without explicit coordination (11, 174–176). Current national nutrition monitoring and surveillance systems face fiscal, infrastructure, and coordination challenges that limit their capacity to respond to evolving data needs, technological advances, and demographic shifts (e.g., barriers to provide sufficient national data for the Congressional mandate in the 2020–2025 DGAs to include infants and women who are pregnant or lactating) (177, 178).

DGAs

A key cross-departmental nutrition-related activity is the DGAs, the cornerstone for many federal nutrition programs and policies (**Supplemental Table 8**) (179). The National Nutrition Monitoring and Related Research Act of 1990 (Public Law 101–445) requires the DGAs be reviewed by the Secretaries of both USDA and HHS. Since 1995, a memorandum of understanding between the 2 departments provides a framework for this joint USDA–HHS endeavor, with each department alternating in leading each 5-y edition (180). Regardless of departmental lead, the USDA CNPP conducts the evidence analysis and develops the corresponding consumer-facing education tools (144, 145). The HHS Office of Disease Prevention and Health Promotion (ODPHP) aims to provide technical expertise and develop DGA-related resources for health professionals.

Both agencies' efforts are constrained by limited funding and staff dedicated to the DGAs (144). In mandating the DGAs, Congress (Public Law 101–445) did not authorize or appropriate any regular funding for the DGA process nor, importantly, for the fundamental research, monitoring, and surveillance processes necessary for developing and translating dietary guidance, among other national needs. For example, there is no consistent funding source to develop the nation's DRIs, which are foundational to the DGAs, nor to ensure sufficient research to develop the necessary evidence base for updates of either the DGAs or DRIs. Successive DGACs from the 1980 edition onwards have documented persistent, major research gaps for setting evidence-based guidelines (181). Consistent funding also does not exist to review the impact of the DGAs on the public's understanding of nutrition, food choices, or health, or on the impact on other stakeholders (181–183).

In response to concerns that the DGA process may require updated processes and coordination, in 2016 Congress instructed the National Academies of Sciences, Engineering, and Medicine (NASEM) to review and make recommendations to the process for updating the DGAs (Public Law 114–113). First, in February 2017, NASEM released "Optimizing the Process for Establishing the Dietary Guidelines for Americans: The Selection Process" (184). This report provided recommendations for how the advisory committee process can be improved to provide more

transparency, eliminate bias, and include committee members with a range of viewpoints. The second report released in September 2017 was entitled "Redesigning the Process for Establishing the Dietary Guidelines for Americans" (182). This report identified the following specific opportunities for improvement in the DGA process: more consistent interpretation of purpose and target audiences of the DGA, greater transparency of the overall process, and more rigorous methodological approaches to the evaluation of the evidence. The USDA-HHS responded to NASEM recommendations in September 2018 indicating changes they will be making in the development of the 2020–2025 DGAs, such as asking for public comments on the topics and scientific questions to be examined in the review of the evidence supporting the development of the next edition (185).

In part to respond to these recommendations, the FY2019 appropriations bill provided a one-time allocation of $12.3 million to CNPP, divided over 3 y, to support the 2020–2025 DGAs (186). These one-time funds are supporting a limited set of systematic reviews of published evidence, but not any new research to address critical knowledge gaps. As previously noted, only ∼1.3% of NIH-supported research focuses on diet for the prevention or treatment of disease in humans, and furthermore, among these, only about half of the projects relate to key research gaps identified by the 2015 DGAC (117–119). In addition, while the 2014 Farm Bill (Public Law 113–79) mandated that the DGAs include, for the first time, food-based nutrition guidance for infants and toddlers aged 0–24 mo and women who are pregnant or lactating (prior DGAs did not include or consider these critical populations), no funding was authorized or appropriated to support this new mandate. Given the first-ever focus of the 2020–2025 DGAs on these important populations, it is expected that the 2020 DGAC will identify even more knowledge gaps for setting national dietary guidance than prior editions (187).

In 1990, Congress specified that the DGAs focus on the general public, not on specific nutritional recommendations for individuals suffering from diet-related conditions (Public Law 101–445). However, highlighting the scale and scope of diet-related illness, only 12% of US adults are metabolically healthy (as defined by blood glucose, cholesterol, blood pressure, and waist circumference). Thus, the DGAs' general focus may exclude the specific dietary needs of the great majority of the US population. Until 2014, the NIH supported the development of evidence reviews and dietary guidance for patients with health issues such as overweight and obesity, high blood pressure, and high blood cholesterol, among others (188, 189). These reviews were used by DGACs with input and endorsement from >25 professional groups. The NIH ceased these reports in 2014, in part because the CDC's mandate deals with disease prevention activities and the mandate of the HHS Agency for Healthcare Research and Quality (AHRQ) includes development of systematic evidence reviews to inform clinical practice guidelines (189–191). Certain nongovernmental professional and clinical organizations provide nutrition guidance for populations with or at risk for various chronic conditions, but these various recommendations are not coordinated (192, 193). The current 2020 DGAC process excludes—for the first time—the use of existing high-quality nongovernmental systematic reviews and meta-analyses conducted by peer-reviewed researchers and major professional organizations. Little work has been done to understand the short- or long-term implications of NIH's shift in 2014 away from dietary guidance for populations with disease conditions, or whether CDC and AHRQ efforts are addressing this gap. Thus, currently no federal entity takes the lead on the development of evidence reviews or dietary guidance for patients with diet-related health conditions. Several organizations, including AND, the National Association for the Advancement of Colored People, and the National Hispanic Medical Association, recently formed the Food4Health Alliance to advocate for additional federal nutrition guidelines tailored to the needs of tens of millions of Americans who have diet-related diseases such as hypertension, obesity, and type 2 diabetes—conditions that also disproportionately affect minorities and underserved communities (194).

In addition to the lack of consistent funding and staff for the evidence reviews, fundamental research, monitoring, and surveillance processes needed to develop and translate dietary guidance, concerns have been raised that the process of updating the DGAs every 5 y is not protected from political or external influences (e.g., political appointees, Congress, food and beverage industries, agribusiness interests, advocacy groups) (182, 184, 195). A coordinated federal approach and authority for nutrition research could help strengthen the process for objective and independent development, review, and dissemination of the best science evidence to the American public in the DGAs for both healthy individuals and those with major diet-related illnesses, as well as for the evaluation of corresponding intended and unintended impacts of these guidelines and needed changes to improve these impacts.

DRIs

DRIs provide specific targets for intakes of relevant nutrients for the general population (196). The first DRIs were created by Presidential mandate in 1941 when President Franklin D. Roosevelt commissioned scientists to generate new minimum dietary requirements for the population to be prepared for World War II (197). In 1943, the first RDAs (a type of DRI) were published, providing science-based guidelines for target intakes of total calories, protein, calcium, phosphorus, iron, and a few vitamins (198). Although DRIs are foundational to DGAs, the Nutrition Facts label, and other federal policies, there is no dedicated funding stream or statutory requirement for updating DRIs. Since the 1940s, DRIs have been updated sporadically dependent on available funding support provided by Congress to federal agencies (e.g., NIH and CDC) and, since the 1990s, additional contributions by the Canadian government (199). NASEM leads the updating of any DRI when requested by the federal government or instructed by Congress. Recently, a NASEM Consensus Study Report determined that crucial research gaps for setting DRIs remain largely unaddressed (200). Another challenge is there is no generally accepted process for deriving dietary reference values, which has led to several-fold differences in international recommendations and decreases their credibility (201, 202). The ICHNR DRI Subcommittee recommended that $2 million annually be placed and held in an agency's budget (e.g., ARS, CDC, and/or NIH) to establish a consistent funding stream for setting and updating of DRIs (203); this recommendation has not been implemented.

Food and nutrition regulatory activities

Nutrition research is foundational for diverse federal, tribal, state, and local food and nutrition regulatory activities including labeling, health claims, food marketing, and oversight of food additives and other constituents (204). For example, Congress in 1990 (Public Law 101–535) authorized the Secretary of HHS to provide consumers with accurate nutrition information on food labels, giving rise to the Nutrition Facts panel. In 1994, the GAO recommended that USDA and FDA work together to perform laboratory analyses to independently verify the accuracy of nutrition labels; review labels for compliance with formatting requirements, nutrient content claims, and health claims; work with companies to correct identified inaccuracies; and where appropriate, pursue legal action against products with inappropriate labels (205). Since that time, USDA and FDA, among other federal departments and agencies, have needed to work together on these topics. Examples include the determination that partially hydrogenated oils (high in industrial *trans* fat) were no longer Generally Recognized As Safe (GRAS), for which NIH- and USDA-funded research, CDC surveillance data, and HHS regulatory reviews supported the FDA determination (206); and FDA's amendment of the food additive regulations to change the standard of identity of enriched flour and corn masa flour (207) to allow folic acid fortification to help prevent neural tube defects in developing infants, which required similar inputs from diverse federal research, surveillance, and regulatory efforts. Another example is the 2016 Nutrition Facts updates (e.g., requiring labeling of added sugar) based on new scientific research, updated DGAs, consensus reports, and national survey data, along with input obtained through proposed rulemaking processes (208, 209).

In 2018, FDA announced their Nutrition Innovation Strategy that outlined key activities to take a "fresh look" at what can be done to reduce diet-related chronic diseases (210). Key elements included the following: modernizing claims such as "healthy," modernizing ingredient labels and standards of identity, implementing the Nutrition Facts Label and Menu Labeling, reducing sodium, and expanding nutrition education (e.g., launching a new Nutrition Facts label education campaign). For example, FDA agreed with a petition that its definition of "healthy," central for marketing regulations, was scientifically outdated and inconsistent with the DGAs and advancing research (211). Insufficient scientific evidence on dietary supplement contents, health effects, and potential risks limits the FDA's ability to provide oversight for this $40 billon/y industry (212–214). As another example, there is no DRI or listing on Nutrition Facts for many compounds that appear relevant for health such as omega-3 fatty acids, phenolics, and other phytonutrients (212, 215). Further, many processing methods and additives banned in the European Union are permitted in the US, based on insufficient science for a definitive determination by FDA (216).

The Federal Trade Commission (FTC) has not been able to engage in any research on the impacts of food marketing to children in nearly 10 y (11). Congress prohibited FTC from completing their joint study with FDA, CDC, and USDA on nutrition standards for food marketing to children, even though this Interagency Working Group on Food Marketed to Children was established by the 2009 Omnibus Appropriations Act (Public Law 111–8) (11). Taken together, these FDA and FTC examples, among others, illustrate the crucial role of robust and coordinated federal nutrition research for numerous regulatory decisions and activities.

Federal nutrition education and promotion

Congress requires federal departments and agencies to coordinate review processes to ensure that nutrition education materials produced by the federal government are consistent with the latest DGAs (Public Law 101–445). This process is facilitated by a Dietary Guidance Review Committee, co-chaired by USDA CNPP and HHS ODPHP. More recently, DoD worked with USDA and HHS to integrate DGAs into their Go for Green® joint-service performance-nutrition initiative that aims to improve the food environment where military service members live and work (217). There is no direct, consistent Congressional investment in nutrition education for the general public, except for limited support of CNPP's dietary guidance translation activities and of USDA Food and Nutrition Service's nutrition education and promotion materials associated with the federal nutrition assistance programs. Over the years, various efforts have examined the impacts of USDA investments in nutrition education and promotion with mixed success (218). A 2019 GAO evaluation found that USDA administers 5 key programs that provide nutrition education but does not have formal coordination mechanisms for its nutrition education efforts and does not fully leverage the department's nutrition expertise (155). The GAO recommended that USDA develop a formal mechanism for coordinating nutrition education, improve the information it gathers on Supplemental Nutrition Assistance Program Education (SNAP-Ed), and take steps to fully leverage the department's expertise for nutrition education efforts.

National nutrition research database

There is no dedicated, consistent funding to identify and track federal investments in nutrition research. In 1981, Congress authorized the Human Nutrition Research and Information Management (HNRIM) system to track funding of nutrition research projects across the federal government (Public Law 97–98). From 1985 to 2015, HNRIM was maintained by NIH and, at its peak, included ≥100,000 records on federal nutrition research and training expenditures. HNRIM was a staff-curated database, with projects identified and classified by expert staff including the proportion of each project actually addressing nutrition. NIH shifted to the more automated NIH Research Portfolio Online Reporting Tools Expenditures and Results (RePORTER) system, which is based on NIH's Research, Condition, and Disease Categorization (RCDC) system to define and categorize research projects across >200 Congressionally mandated categories (Public Law 109–482). RCDC uses automated text data mining to match federal research projects to spending categories. The RePORTER system then assigns the total dollar amount of any research project that may be related to nutrition to the category of "nutrition research." Most research projects meet criteria for and are counted across multiple categories. For instance, a single project and its total dollars may be counted as 100% nutrition, obesity, cardiovascular disease, diabetes, and prevention, among others. Besides NIH systems, a variety of other websites and databases aim to capture federal investments in human nutrition

research, each using different methods with uncertain accuracy (**Supplemental Table 9**).

Current landscape: summary

Significant efforts are occurring across diverse federal departments and agencies to leverage existing personnel and funding and coordinate existing activities to advance nutrition research. However, these efforts are not sufficiently coordinated or expansive enough to address the current and future diet-related disease burdens, or the corresponding health care spending, food insecurity and health disparities; strains on government budgets and American businesses; challenges to military readiness; and intersections with supply chains and sustainability. Many new opportunities exist to be seized, as reviewed next.

The Opportunity

A strengthening of federal nutrition research has significant potential to generate new discoveries to improve and sustain the health of all Americans. We identified and collated multiple specific priority areas that have been set forth by various federal and nongovernmental organizations (**Table 2** , Figure 2), and most of these have not been adequately addressed (11, 81, 147, 196, 219–226).

Cross-governmental strategic planning and prioritization

An expanded, coordinated federal nutrition research effort could more effectively plan and prioritize scientific discoveries across critical areas. In addition to existing priorities, such an effort would create capacity to quickly identify and address timely new scientific challenges and opportunities as they arise. Improved cross-governmental coordination would also facilitate interdisciplinary research and its societal impact. This would include accelerated translation of scientific findings into practice—for example, relevant for USDA nutrition assistance programs, FDA regulatory activities, CMS health care improvements, CDC public health efforts, DoD and VA priorities for active-duty forces and veterans, USDA agricultural priorities, and additional interests of communities, schools, and worksites. Cross-governmental coordination would also provide leadership to help develop effective public–private partnerships. A coordinated federal nutrition research authority would also facilitate appropriate expertise on review panels to identify meritorious projects and multidisciplinary investigative teams to achieve project goals and foster the development and application of high standards for scientific rigor, reproducibility, and transparency (11, 227).

Greater science for dietary guidance to the public

While current science permits broad recommendations on healthy eating patterns, significant scientific debate and public confusion remain on many topics. As reviewed earlier, the 2015 DGAC identified numerous critical areas for national dietary guidance that require greater scientific evidence (Supplemental Table 2). A 2020 DGAC member described their continuing inability to draw many conclusions from an inadequate evidence base in 2 words: “It’s disheartening” (228). Similar opportunities exist for greater scientific investments to allow regular DRI updates (200). Additional areas for accelerated research include major food groups for which health effects are currently poorly understood, and the interrelationships between nutrition and the gut microbiome, immunity, epigenetics, vascular health, food allergies, and other physiological systems—all with tremendous implications for human health (229–232). The complex effects of nutrition on health, the often provocative messages from the media and other influencers, and the many real unanswered and emerging questions in nutrition science have created significant public confusion (233). As a result, the public is awash with insufficient and conflicting information on many topics, such as on popular diets for weight loss, the effects of caloric restriction or intermittent fasting, and many other topics, with limited rigorous science to provide confident guidance. A broadly expanded and coordinated effort to generate and disseminate scientifically sound nutrition research is an essential need for the American people.

Leverage new technologies and data science

Exponential growth has occurred in technology, genomics, proteomics, and metabolomics platforms; personalized and environmental sensors; and other big-data resources. Yet, the implications of these advances for a new era of nutrition research have not been realized. Strategic planning across the federal government would help mobilize limited resources for maximizing this high-cost area of research. As one example, while diverse federal departments and agencies [e.g., NIH, USDA, DoD, FDA, National Science Foundation (NSF), VA] have expressed great interest in personalized or precision nutrition (234), inadequate funding and coordination have hampered the nation’s ability to fully leverage and harness the potential of the powerful, expensive ’omics platforms and related data science advances to develop personalized recommendations (235). The untapped potential of new technology and data science approaches extends far beyond precision nutrition, with promise for additional basic, clinical, environmental, and public health research on food and nutrition (236).

Foundational basic science and discovery

Fundamental research in nutrition is essential to accelerate progress but is hampered by the absence of any federal home for its investment and coordination. For example, little is known about the molecular basis of varying nutritional needs across continua from birth to older age, health to disease, or inactive to active lifestyles (11). Pathways of nutritional influences during the first 1000 days of life, when critical metabolic programming can alter lifelong and possibly epigenerational disease risk, remain critically understudied (237). Food allergies have exploded among US children, yet with little understanding of their underlying determinants or effective preventive measures (238). The molecular and metabolic influences of food on aging—including frailty, suppressed immune responses, brain function, sarcopenia, macular degeneration, renal decline, and functional decline—are essential areas of research for an aging population (11). Thousands of poorly characterized bioactive compounds in foods, such as flavanols and other phenolics, require basic research to elucidate their biochemical and physiologic effects. Accelerated basic research is also essential to assess the molecular and health impacts of other factors such as food additives, gluten, FODMAPS (fermentable oligo-,

TABLE 2 Opportunities for enhanced federal nutrition research coordination and investment[1]

Cross-governmental strategic planning and prioritization
- Develop a national strategic planning process including optimal leadership, coordination, monitoring, and funding structures
- Develop criteria for prioritization such as based on population impact, feasibility, emerging scientific opportunities and methodologic advances, and relevance for cross-governmental regulatory priorities
- Enhance the scope, interdisciplinary nature, and impact of individual research projects and research initiatives
- Accelerate translation
- Develop new research mechanisms and transparent private–public partnerships that stimulate and reward science-driven innovations for health, health equity, and sustainability
- Develop common guidance and standards on project reviews and scientific rigor, reproducibility, and transparency

Advance the science for dietary recommendations to the public
- Comparative effects of different popular diet patterns, eating frequency, intermittent fasting, and diet quantity vs. different foods on weight loss and weight maintenance; and heterogeneity in these effects based on a person's characteristics
- Optimal dietary recommendations for specific disease conditions, such as hypertension, type 2 diabetes, cardiovascular diseases, specific cancers, infections, autoimmune diseases, and more
- Rigorous studies on food groups with unclear or controversial evidence, such as different dairy foods (cheese, yogurt, milk, butter), red meats, tropical oils, organic vs. nonorganic foods, among others
- Numerous other critical areas requiring more scientific evidence as identified by the 2015 DGAC (see Supplemental Table 2)
- A stronger intergovernmental process and more consistent funding for establishing DGAs and DRIs

Leverage new technologies and data science resources and approaches
- Interactions between diet, the gut microbiome, immunity, epigenetics, vascular health, and other physiological systems
- Personalized or precision nutrition, including based on personal backgrounds, habits, genes, microbiomes, medications, and chronic medical conditions
- Interrelationships of nutrition and epigenetics for health
- Using innovative technology and data science for diverse fundamental, clinical, environmental, and public health research questions in food and nutrition

Advance foundational and basic science knowledge and discoveries
- Molecular basis of nutritional needs across the lifespan, physical activity levels, and disease conditions
- Pathways of nutritional effects in the first 1000 days of life for programming of lifelong health
- Origins of and treatments for food allergies
- Optimal nutrition for healthy aging
- Nutritional treatments for reducing side effects of and more effectively targeting cancer chemo- and radiation therapy
- Comprehensive characterization of and molecular and health effects of trace bioactives and phenolics, such as in extra-virgin olive oil, cocoa, green tea, coffee, red wine, and blueberries, among others
- Assessing the molecular and health impacts of additives, gluten, FODMAPS (fermentable oligo-, di-, mono-saccharides and polyols), low-calorie sweeteners, and other food components of public interest and confusion
- Assessing the opportunities, controversies and confusion around food processing and processed foods

Understand and address diet-related health disparities
- Community-based participatory research to understand and address community priorities around nutrition
- Influence of the food environment, and intersections with individual and social determinants, of diet-related health disparities, and the corresponding translational solutions
- Causal interrelationships between food insecurity and diet-related chronic diseases like obesity, diabetes, cardiovascular diseases, and certain cancers
- Influence of education, knowledge, personal choice, sociocultural influences, industry marketing, and diverse food environment characteristics
- Roles of past and current discriminatory policies and practices that alter employment opportunities, homeownership, and community development

Support and enhance translational and implementation science
- Intersections of nutrition with shared risk factors such as low physical activity and tobacco use, among others
- Developing effective behavior change strategies and policy, systems, and environmental supports for promoting healthy eating
- Understanding characteristics of effective communication channels for diverse audiences
- Enhancing nutrition science literacy
- Rigorous evaluation of the major federal investments (DGAs, food labeling, health claims, menu labeling, SNAP-Ed, etc.) for informing public choices around nutrition
- Nutrition policy and food environment research including efficacy, cost-effectiveness, equity, and feasibility
- Coordinated interagency research on food marketing to children
- Strengthen medical nutrition therapy for an array of acute and chronic diseases and conditions
- Coordinated interagency research on Food is Medicine interventions within health care systems, including medical and other allied health professional education, medically tailored meals with enhanced medical nutrition therapy, produce prescriptions, and other nutrition-focused flexible benefit services

Coordinate key cross-agency research priorities for nutrition-related investments
- Optimizing nutrition-related investments for diplomacy, development, and defense, such as by USAID ($27 billion/y)
- DoD priorities around nutrition for human performance, military readiness, and treatment of musculoskeletal and battlefield injuries
- VHA opportunities to reduce high rates of diet-related illnesses among veterans
- Understand and define basic nutrient requirements during extended stays in microgravity, among other research and translation needs to support NASA astronauts
- Strengthen and leverage the nearly $100 billion/y national investment across ≥15 USDA nutrition assistance programs
- Food safety research, relevant to FDA, USDA, and NIH
- FDA regulatory issues including Nutrition Facts labeling, front-of-pack labeling, restaurant menu labeling, health claims, food category standards of identity, cellular agriculture, food additives, and dietary supplements
- Intersections of nutrition science and food, nutrition, and health regulatory activities coordinated between FDA, USDA, NIH, among others

Intersections with food production, supply chains, and sustainability
- Interplay of livestock and farming practices on the joint nutritional quality of foods and natural resource use
- Nutritional innovations and collaborations for healthier crops and manufactured food products including novel ingredients and biofortification as a means to increase nutrient content and availability
- Nutritional implications of novel regenerative agriculture approaches
- Impacts of plant-based meat and dairy alternatives and cellular agriculture on health and sustainability
- Joint impacts of climate on nutrition, production, and resource use

(*Continued*)

TABLE 2 (*Continued*)

Monitoring and surveillance
• Diets and health nationally, by state, and in population subgroups
• Food security and diet-related health disparities, including monitoring food access and affordability
• Neighborhood food environments, school meals, and retail and restaurant purchases
• Nutritional aspects of federal nutrition assistance programs
• Structures, strengths, and weaknesses of local, regional, national, and global supply chains

[1]These examples were identified and adapted from several governmental and nongovernmental consensus recommendations on current priority areas for new nutrition research along with an assessment of additional research literature (11, 81, 147, 196, 219–226). DGA, *Dietary Guidelines for Americans*; DGAC, Dietary Guidelines Advisory Committee; DoD, Department of Defense; FODMAPS, fermentable oligo-, di-, mono-saccharides and polyols; NASA, National Aeronautics and Space Administration; SNAP-Ed, USDA Supplemental Nutrition Assistance Program Education; USAID, US Agency for International Development; VHA, Veterans Health Administration.

di-, mono-saccharides and polyols), low-calorie sweeteners, and other food components of public health interest.

Diet-related health disparities

Many health disparities are closely linked to nutritional disparities (71–73, 239). Hunger and food insecurity remain pervasive in the US, with great costs for society and our health care system (76, 218, 240, 241). Yet, while it is now evident that calories alone are an insufficient solution, scientific understanding remains limited on the causal intersections of food insecurity and risk of diet-related chronic diseases, and on the optimal nutritional and other translational approaches to address these challenges (78, 80, 240, 242). As noted earlier, nutrition-related health disparities experienced by low-income, rural, and minority populations are influenced by a complex and insufficiently understood intersection of individual, sociocultural, and environmental determinants (77–80). Community-based participatory research holds promise as an approach to better understand and address community priorities around nutrition (243, 244). Research priorities for greater investment and cross-agency coordination include the influence of context on food-related decisions and behaviors across diverse retail food environments, including but not limited to the influence of price and marketing, food access and availability, transportation options and use, perceptions of neighborhood and traffic safety, rapidly growing online purchasing including with federal nutrition programs, the short- and long-term impacts of the Public Charge Rule on federal nutrition assistance participation, and the influences of past and current discriminatory policies and practices impacting employment opportunities, homeownership, and community development (218, 245–256).

Translational and implementation science

Major research initiatives are needed to better understand how eating behaviors can be positively influenced in diverse populations. Translational research must identify optimal strategies to leverage the food environment, including retail settings, schools, worksites, health care systems, nursing homes and assisted-living facilities, and federal nutrition assistance programs for better nutrition (257, 258). In the 2015 DGAC report, for example, the scientific evidence was considered limited or not assignable for many crucial translational questions, such as whether food insecurity affects body weight; whether acculturation influences diet, body weight, or cardiovascular risk factors; whether menu calorie labels influence food selection or consumption; or whether access to farmers' markets, supermarkets, grocery stores, or convenience/corner stores influences dietary intakes, diet quality, or body weight (Supplemental Table 1).

Implementation research is also crucial to assess and optimize intended benefits of the numerous federal policies and investments around public communication and education, including the DGAs, food labeling, health claims, menu labeling, and SNAP-Ed. This should include coordinated research efforts on evidence-based nutrition education and promotion strategies for healthy populations (the current focus of the DGAs), those with specific diet-related illnesses (the majority of the US population, but not included in the DGAs), and those with resource limitations and food insecurity (194, 259, 260). Understanding how and why effectiveness of communication channels may vary, such as according to print or health literacy, numeracy, culture, income, or neighborhood (e.g., food access), is critical. Effective approaches to increase nutrition science literacy can be assessed through new and enhanced research collaborations, such as between the DoE, USDA, NIH, and CDC. As one example, enhanced collaborations with DoE could include efforts to study potential improvements to food-, nutrition-, and health education–related curricula, testing, school environments, and teacher preparation. In addition, more research is needed across the policy development and dissemination spectrum to advance our understanding of efficacy, cost-effectiveness, equity, and feasibility of policy, systems changes, and environmental supports that promote healthy eating (241, 261–263). Coordinated interagency research is also needed on the effects and appropriateness of food marketing to children (e.g., between the FTC, CDC, FDA, and USDA). Together, such research can inform both current and alternative federal approaches for disseminating evidence-based information to inform choice and reduce confusion among a public hungering for scientifically sound guidance.

Translational research is also needed to leverage allied health professionals and the health care infrastructure to reduce diet-related illnesses. Innovative translational and implementation science research has tremendous potential to strengthen medical nutrition therapy led by registered dietitian nutritionists for an array of acute and chronic diseases and conditions (11, 264–267). Many other promising strategies warrant significant research, including the following: expanding the integration of food security and diet quality assessments into electronic medical records or Fast Healthcare Interoperability Resources, updating of medical and other health care licensing and certification standards to include nutrition education, assessing health and cost impacts of medically tailored meals and produce prescriptions,

and leveraging Medicaid flexible benefit services and Medicare Advantage for better nutrition and health (268, 269). The rapidly growing private and public interest and investment in such "Food is Medicine" approaches must be informed by robust research. Strengthened coordination of research priorities and investments across CMS, CMMI, CDC, Health Resources and Service Administration (HRSA), NIH, and USDA, among others, can inform how best to engage in these strategies together with the allied health community in real-time. In addition, more research is needed across the policy development and dissemination spectrum to advance our understanding of efficacy, cost-effectiveness, equity, and feasibility of policy, systems changes, and environmental supports that promote healthy eating.

Key cross-agency research priorities for nutrition-related investments

Coordinated research is also important to better leverage the many federal investments in nutrition. This includes the $27 billion annual investment in USAID, 1 of the 3 foundational pillars for promoting and protecting US national security interests abroad, for which expanded research in nutrition and agricultural innovation is central (11, 270, 271). The DoD also has key nutrition research priorities around human performance and military readiness that would benefit from cross-agency coordination (11). Increased investment in nutrition research would also benefit many active-duty families who suffer from diet-related chronic illnesses as well as often coexisting food insecurity (87–91). The majority of veterans receiving care at VHA, the largest integrated health care system in the US, suffer from ≥1 diet-related conditions (86). NASA conducts some of its own nutrition research but relies heavily on other federal departments and agencies to help define nutrient requirements and healthy eating strategies for extended space exploration (11). Other cross-governmental opportunities for coordinated nutrition research include how best to strengthen and leverage the nearly $100 billion annual national investment in USDA nutrition assistance programs (241) and research on food safety, a joint FDA and USDA priority. Many other FDA regulatory actions require robust research findings, yet are often limited by incomplete evidence. This includes decisions on Nutrition Facts labeling, front-of-pack labels, restaurant menu labeling, health claims, dietary supplements, food additives, standards of identity (e.g., around plant-based dairy and meat alternatives), and cellular agriculture (210). An expanded federal nutrition research effort to better support regulatory actions could create renewed industry support for nutrition research as well as interest in developing innovative public–private partnerships (272).

Intersections with food production, supply chains, and sustainability

The federal government has many priorities around US farming, rural development, food production, food manufacturing, and supply chains (9, 156, 157). Nutrition research intersects with each of these, such as on how to increase production of and access to affordable, healthful food; develop technologies and collaborations to produce new high-value products for farmers and food manufacturers; foster public–private partnerships for innovation and adoption of novel technologies; and expand technology development and other entrepreneurship efforts between academic institutions and small businesses (147). As summarized in earlier sections, fundamental research questions are also emerging on how food production jointly intersects with human and planetary health, including effects of different strategies for plant and animal breeding, livestock and farming practices, regenerative agriculture, production of plant-based meat and dairy alternatives, and cellular agriculture (11, 156, 273).

Monitoring and surveillance

Nutrition-related monitoring and surveillance are critical to inform nutrition research, which then bidirectionally guides surveillance priorities (11, 274). The COVID-19 crisis has highlighted the fragmented and often incomplete national infrastructure for monitoring food- and nutrition-related questions in real time, including, for example, information on local, regional, and national food insecurity; dietary choices; diet-related health disparities; neighborhood food environments; and supply chains (3–9). Expanded and modernized monitoring and surveillance are essential components of a strategy to strengthen and better coordinate federal nutrition research.

Return on investment

The ROI for federal research has been documented across several metrics (275). Considering commercial innovation, ∼1 in 12 NIH grants directly lead to patents, while ∼1 in 3 granted patents cite NIH-funded research (276). In a 2012 analysis, each $1 increase in NIH funding was estimated to increase the size (output) of the bioscience industry by between $1.70 and $3.20 (277). A $3.8 billion federal investment in the human genome project plus an additional $8.5 billion in related research and support have been estimated to produce nearly $1 trillion of economic growth, amounting to a 180-fold ROI (278). In 2014 Senate testimony, NIH Director Francis Collins reported that NIH funding supported >402,000 jobs and $58 billion in economic output nationwide, whereas NIH discoveries contributed $69 billion to GDP and supported 7 million jobs in 2011 (279).

Our review suggests that expanded federal coordination and investment in nutrition research will generate similarly meaningful ROI. Opportunities include more efficient leveraging of existing nutrition research infrastructure and investments, as well as other current federal investments in nutrition-related programs and policies at USDA (∼$100 billion/y), USAID (∼$27 billion/y), DoD, VA, FDA, CDC, CMS, FEMA, and more. Such investments could also be crucial to help reduce population diet and health inequities across diverse population subgroups.

One of the most promising areas for ROI would be advancing basic, clinical, and implementation science to reduce diet-related diseases. As mentioned in earlier sections, a recent NIH prevention research portfolio analysis compared national risk factors for death with NIH research investments (120). The largest gap was for nutrition, which was the top cause of attributable deaths (estimated to cause 19.1% of all deaths) but represented only 6.7% of all NIH prevention research

funding (~$0.43 billion based on the 2019 NIH budget, or ~1.1% of all NIH funding) (117, 120). In comparison, estimated government spending on direct health care for diabetes alone was ~$160 billion/y in 2017, with an expected growth rate of 5% (~$8 billion) per year (280). Medical care for people with diagnosed diabetes accounts for ~1 in 4 health care dollars in the US, with more than half of these costs being directly attributable to diabetes (280). And, while mounting evidence suggests that severity, complications, and costs of type 2 diabetes can be rapidly reduced through better lifestyle including dietary changes (281–284), the optimal dietary priorities, behavior change strategies, microbiome implications, and personalization needs to most effectively improve diabetes remain uncertain. A major effort to expand and harmonize federal nutrition research could have rapid ROI based on reduced health care costs alone. For instance, a new, additive $1–2 billion annual investment in nutrition research could potentially generate a several-fold ROI if this helped flatten the anticipated ~$8 billion/y annual increase in government expenditures on medical care for diabetes (280). Estimates of potential ROI of expanded federal nutrition research can be considered against health care and other societal costs of other diet-sensitive conditions, such as hypertension, food allergies, coronary heart disease, certain cancers, and more. As stated by the FDA Commissioner in 2018, "Improvements in diet and nutrition offer us one of our greatest opportunities to have a profound and generational impact on human health … The public health gains of such efforts would almost certainly dwarf any single medical innovation or intervention we could discover" (285).

Greater coordination and investment in federal nutrition research could also catalyze and unlock economic growth through new public–private partnerships and new private capital investment, small businesses, jobs, and inventions. In addition to potential for lower health care spending, accelerated nutrition research could help foster a healthier and more productive workforce, more active and thriving children, and healthier and more independent seniors. New research investment and structure should also support the training of a new generation of scientists and health care professionals who can leverage nutrition-related knowledge for public good. Enhanced nutrition science and cross-governmental authority can also strengthen dietary guidance, reduce public confusion, and improve consumer food choices.

Together with increased investment in food and agricultural research, strengthened multidisciplinary nutrition science could better support the long-term economic vibrancy of US farmers and rural communities. Past increases in agricultural productivity, for example, have come almost entirely from science-based innovations (146). Such integrated efforts would also be able to address the critical emerging nexus of health, food, agriculture, climate, and sustainability (147, 286, 287), positioning the US as the global leader in this area. This would further improve stewardship of US natural resources, including water, soil, forests, and oceans. In sum, this would strengthen long-term US food security, farmers' incomes, national and rural economic growth, and resilience of the food and agricultural sector, which accounts for 1 in 9 US jobs (288).

Appropriate federal investment and coordination of nutrition research could improve national resilience against chronic threats and acute crises. The COVID-19 pandemic highlights the need to have a coordinated, vigorous scientific research infrastructure before crises strike (3–8). The bidirectional impacts between food and nutrition and COVID-19 have also revealed a vital new area for research and policy that requires significant investment and coordination (289).

In 2019, the Director of National Intelligence reported to Congress that our national disinvestment in science and technology is 1 of 10 global threats because, without the research to produce disruptive US technologies, we weaken our economic competitiveness (290). A new structure for coordination of existing federal nutrition research, combined with a major new investment—for example, increasing federal nutrition funding by $1–2 billion or more each year—could together provide highly cost-effective approaches to addressing the poor health, rising disparities, spiraling health care costs, declining qualified military recruits, and other pressing food and agricultural challenges facing the US.

Options for Strengthening National Nutrition Research

Based on our review, a strengthened federal nutrition research effort is necessary and should be additive to and synergistic with existing efforts across departments and agencies. Expanded coordination and investment in nutrition science, rather than a silo-ing of nutrition research or a rearrangement of existing investments, are essential. Based on the documented burdens, current landscape of research and coordination efforts, and identified opportunities, we first identified 2 priority strategies to strengthen federal nutrition research, which we defined and reviewed in detail. These were as follows: *1*) a new authority for robust cross-governmental coordination of nutrition research and other nutrition-related policy and *2*) strengthened authority, investment, and coordination for nutrition research within NIH.

These 2 strategies were identified as complementary, with benefits accruing independently and further synergies to be gained by joint implementation. A third important, and further complementary, identified strategy was to strengthen authority, investment, and coordination at USDA for human nutrition research, food and agricultural research, education, extension, and economics.

To achieve success, a key identified theme was the need for not just additional investment but also new authority and structure. Multiple assessments over many decades have identified the fundamental need to strengthen federal nutrition research in the US. This includes, among others, the 1969 White House Conference; the 1977 Congressional call for improved coordination of human nutrition research; the 1983 creation of ICHNR; the 1994 Institute of Medicine report on nutrition and food sciences; the 1996 joint OSTP and the National Science and Technology Council (NSTC) report on health, safety, and food; the 2000 National Nutrition Summit; and more (Supplemental Table 5 and **Supplemental Table 10**). Several within- and cross-agency convenings of federal departments and agencies have further identified critical shared interests and research gaps in nutrition research (Table 2). Yet, the full intended impacts of these important efforts were mostly not achieved, in large part because they lacked any new federal structure with strong and

sustained authority, robust coordination capacity, and dedicated appropriations.

The following sections describe the identified promising options for strengthening nutrition research through *1*) increased cross-governmental coordination; *2*) increased authority, investment, and coordination within NIH; and *3*) increased authority, investment, and coordination at USDA. The majority of these options are being set forth for the first time and, where possible, we reference comparable examples.

Identified cross-governmental coordination strategies for strengthening national nutrition research

Improved coordination between federal departments and agencies conducting nutrition research has tremendous potential for strengthening our nation's ability to achieve essential fundamental, clinical, public health, and translational discoveries. Key identified strategies are summarized in **Table 3** and reviewed below. These options were not found to be mutually exclusive and could be even more effective in combination.

New Office of the National Director of Food and Nutrition.

Modeled after the Office of the Director of National Intelligence (ODNI) (291), but with a smaller budget and staffing scale, an Office of the National Director of Food and Nutrition (ONDFN) would provide essential coordination and harmonization of the work of the ≥10 US departments and agencies comprising the federal nutrition community (**Supplemental Figure 3**). ODNI is a crucial office created as part of the Intelligence Reform and Terrorism Prevention Act of 2004 (Public Law 108–458) to lead and integrate the diverse intelligence efforts of 16 departments and agencies. Working as one team, ODNI helps synchronize intelligence collection, analysis, and counterintelligence, forging a harmonized system to deliver the most insightful intelligence possible. ODNI prioritizes intelligence-community-wide mission requirements, manages strategic investments to foster innovation and efficiency, evaluates the effectiveness of intelligence programs and spending, and absorbs new missions and develops new capabilities without adding to staff size. Nearly half (40%) of ODNI staff are on rotation from 1 of the 16 participating departments and agencies. Of note, the combined budgets of ODNI members ($50 billion/y) are of a similar scale as the overall current nutrition-related programs (including research) of ICHNR members.

ONDFN would be led by a new, cabinet-level Director of National Food and Nutrition, serving as the Principal Food and Nutrition Advisor to the White House, heads of executive branch departments and agencies, senior military commanders, and Congress. Similar to ODNI, ONDFN functions would include reviewing and coordinating priorities and strategies to maximize nutrition research efforts across various federal investments; establishing objectives and priorities for the collection, analysis, and dissemination of national nutrition monitoring and surveillance; ensuring provision of accurate and timely nutrition information to decision makers; evaluating and improving the effectiveness and synergies of federal nutrition research and policy efforts; overseeing the coordination of external advisory groups and public–private partnerships around nutrition research and policy; developing policies and programs to leverage the distinct efforts of departments and agencies around nutrition; and developing and reporting on performance goals and program milestone criteria.

Advantages. This tested and successful model is on a comparable area of national importance and with a similar size and breadth of relevant involved departments and agencies. ONDFN would build on ICHNR, but with a much stronger platform to create effective coordination and synergies. ONDFN would deliver relevant harmonized information to the President, Cabinet, other executive branch leadership, senior military commanders, and Congress for developing policy, programmatic, and budget initiatives. A clear Congressional mandate would provide cross-agency coordination of strategic planning, programmatic review, annual reporting and quadrennial assessments to the President, Congress, and other key stakeholders, budgetary needs, and external research and cooperation. There could also be additional Congressional oversight as needed and interests arise. ONDFN would also provide dedicated leadership and staff in the executive branch cabinet for federal nutrition research and policy, providing a crucial bridge between research and implementation. These activities and personnel would more efficiently and effectively help identify topics of strategic interest across multiple departments and agencies with significant impact and feasibility, and advance emerging opportunities to accelerate progress across new fundamental and transactional scientific topics. A broad focus would increase synergies, shared priorities, and effectiveness and efficiency of different departments and agencies engaged in activities related to innovation in nutrition, agriculture, and food systems.

Like ODNI, a meaningful number of staff would be drawn from existing departments and agencies, creating budgetary efficiencies while maximizing cross-fertilization of ideas and innovations. ONDFN would have the infrastructure and authority necessary for true cross-department/agency coordination—for example, to develop a modernized approach to the nexus between the agriculture-food-health value chain—including research, policy, and practice from farm inputs and food processing/production to consumer behavior to human health. ONDFN would also advance the coordination for communication of trusted nutrition information to the American public, which occurs across separate departments and agencies including CMS and VHA (health care providers), USDA (DGAs, SNAP-Ed, WIC education, food safety for meat and poultry), FDA (food safety for other foods, Nutrition Facts, health claims, package warning labels, restaurant menu labeling), NIH (scientific studies), DoE (nutrition and STEM curricula), CDC (school, community, and public health nutrition education), and more. This would help meet the almost explosive growth in public demand for better information on the science of diet-related health. ONDFN would combine a national food strategy with coordinated new science, considered crucial to better harmonize law and policymaking around food and agriculture, food safety and nutrition research, and establishing, prioritizing, and pursuing common goals (292). Such a strategic plan would create transparency and accountability, including tasks of identifying and monitoring budgets and metrics of success across its purview. A high-level, cross-governmental structure like ONDFN would also be crucial for effective and timely responses on urgent nutrition and food

TABLE 3 Key cross-governmental coordination strategies for strengthening and accelerating national nutrition research[1]

Option	Description	Advantages	Disadvantages	Paths forward
New Office of the National Director of Food and Nutrition (ONDFN)	• President-appointed, Senate-confirmed Director, serving as the Principal Nutrition Advisor to the White House, heads of executive branch departments and agencies, senior military, and Congress • Modeled after the Office of the Director of National Intelligence • Coordinate and harmonize the work of the ≥10 US departments and agencies that comprise the federal nutrition community • Ensure that timely and objective national nutrition information is provided to key federal leaders	• Tested, effective model • Dedicated leadership, staff, and funding • Builds on the ICHNR, with much stronger coordination and synergies across departments and agencies and a stronger dissemination platform • Can be mobilized to advise on urgent situations (e.g., COVID-19) which require pre-existing robust leadership and coordination across departments and agencies	• Focus on multiple nutrition issues could dilute relative focus on research and innovation • May be too high-level to address on-the-ground infrastructure and investment needs of key research agencies	• Congressional authorization and appropriation • Presidential appointment of the Director, with Senate confirmation
New US Global Nutrition Research Program (USGNRP)	• Charged with improving coordination and integration of federal research on food and nutrition and the implications for the nation • Modeled after the US Global Change Research Program • Overseen by the Executive Office of the President and facilitated by a National Coordination Office • Funded by a small portion of relevant research budgets from the participating departments and agencies	• Tested, effective model • Dedicated structure, staff, and budget • Builds on the ICHNR • Renewed and clear mandate for coordination, with explicit requirements for strategic planning, rigorous assessments, and annual reporting	• Budget dependent on size and commitment of participating departments and agencies to its research area • Staffing dependent on detailed personnel from participating departments and agencies, reducing continuity	• Presidential Initiative (with or without subsequent Congressional codification) • Congressional authorization, ideally associated with Congressional appropriations
New Associate Director for Nutrition Science in the White House Office of Science and Technology Policy (OSTP)	• Non–cabinet-level position, President-appointed and Senate-confirmed • Serves as the President's advisor on issues related to nutrition research • Modeled after other Associate Director positions and initiatives • Provides high-level leadership and harmonization to leverage and translate federal and nonfederal nutrition research efforts • Identify and help develop more coordinated and innovative nutrition research initiatives	• Brings a key leader to the White House for improved coordination, communication, and strategic planning • Elevates work and impact of individual federal departments and agencies and the ICHNR • Can hire advisors, special assistants, and fellows to deepen expertise and impact • Creates collaborations with private sector, state and local governments, academic communities, other countries	• OSTP positions can vary greatly from one administration to the next, greatly limiting long-term continuity and success • OSTP initiatives may not align with focus or levels of research funding • Staffing often small, transient, and reliant on temporary staff • Success highly dependent on the skills and interests of the hired person	• Presidential appointment, with Senate confirmation

(*Continued*)

TABLE 3 (*Continued*)

Option	Description	Advantages	Disadvantages	Paths forward
New US Task Force on Federal Nutrition Research	• Charged with improving coordination and integration of federal nutrition research • Modeled after the successful US Task Force for Combating Antibiotic-Resistant Bacteria • Co-chaired by the Secretaries of HHS, USDA, DoD, and possibly VA, with additional broad membership from other departments and agencies • Complementary Presidential Advisory Council • Would develop a 5-y National Action Plan with required annual reporting to the President on progress	• Tested, successful model • Executive Order would elevate federal prioritization of nutrition research • Cabinet-level leadership • Concrete National Action Plan with required annual reports • Advisory Council to leverage external expertise • Strengthen coordination, communication, and budgetary priorities toward the highest-impact shared agenda	• Presidential Executive Order often does not bring or align with dedicated funding • More transient in nature, with defined scope and time period	• Presidential Executive Order • Presidential directive to revise the ICHNR structure • Congressional inquiry on the above actions • Legislation to revise the ICHNR charge, structure, and funding

[1]COVID-19, coronavirus disease 2019; DoD, Department of Defense; HHS, Department of Health and Human Services; ICHNR, Interagency Committee on Human Nutrition Research; VA, Department of Veterans Affairs.

challenges during complex situations like COVID-19, which require immediate and ongoing leadership and coordination at the highest levels of the government (9, 293).

Disadvantages. This new position and office would require Congressional (legislative) authorization and appropriations. As a cabinet-level office, ONDFN would naturally focus on major federal nutrition issues beyond research (e.g., nutrition assistance programs), which could dilute its relative focus on research and innovation. ONDFN may also be too politically high-level to directly address ways to strengthen on-the-ground infrastructural and investment needs within key federal nutrition research departments and agencies.

Path forward. Congress can authorize the establishment of ONDFN to advise the President on food and nutrition and lead the coordination of multiple federal departments and agencies, policies, budgets, and programs. The mandate should include a clear emphasis on strengthening national nutrition research. Congress would also appropriate funding to establish this Office and then provide annual appropriations directly to the ONDFN. Congress would also indicate the required frequency of reporting (e.g., annual reporting and quadrennial assessments) and indicate the committees of oversight in the House and Senate. The President would then appoint the National Director of Food and Nutrition.

New US Global Nutrition Research Program.

A new US Global Nutrition Research Program (USGNRP) would be charged with improving coordination and integration of federal research on food and nutrition and implications for the country (**Supplemental Figure 4**). The USGNRP would be modeled after the successful US Global Change Research Program (USGCRP), established in 1989 by a Presidential Initiative and codified in Congress through the Global Change Research Act of 1990 (Public Law 101–606) (294). This Act required a comprehensive and integrated US research program to assist the nation to assess, predict, and respond to human-induced and natural processes of global climate change. Bringing together 13 departments and agencies, USGCRP is steered by the Subcommittee on Global Change Research under the Committee on Environment, Natural Resources, and Sustainability, overseen by the Executive Office of the President, and facilitated by a National Coordination Office (295). USGCRP has its own budget that mainly supports the National Coordination Office, staffed with professional coordination support staff. USGCRP is supported by statute through small apportions of participating departments' and agencies' research funding dedicated to climate issues (296). Guided by a series of multi-stakeholder strategic plans since 1989 (297), the efforts of participating departments and agencies are coordinated through Interagency Working Groups that span interconnected topics. Annual USGCRP reports and other scientific assessments and resources highlight key program accomplishments, such as observing and understanding changes in climate, the ozone layer, and land cover; identifying impacts of these changes on ecosystems and society; estimating future changes in the physical environment, and associated vulnerabilities and risks; and providing scientific information to

enable effective decision making to address corresponding threats and opportunities (297).

Similar to USGCRP, USGNRP leadership would be overseen by the Executive Office of the President. Likewise, its National Coordination Office would be staffed by dedicated staff and temporary ("detailed") staff from participating departments and agencies, and funded by small portions of relevant research budgets from each participating department and agency. In addition to current ICHNR members, USGNRP could include a more contemporary vision of federal stakeholders who engage with and leverage nutrition research, such as CMS, CMMI, HHS Office of the Surgeon General, FEMA, and Departments of Veterans Affairs, Education, Energy, Transportation, Labor, Homeland Security, Housing and Urban Development, Interior, and Justice (e.g., related to optimal nutrition in the federal prison system). Like USGCRP, functions of USGNRP would include multi-stakeholder–informed strategic planning; Interagency Working Groups to identify and coordinate shared priority research and translation; assessment and modernization of nutrition monitoring and surveillance; and creating partnerships with academic, private, and international science stakeholders.

Advantages. This is a tested, successful model on a similarly crucial area of science. USGNRP could build on ICHNR but with the establishment of a dedicated budget from participating departments and agencies. Through strategic planning, new and additive budget initiatives could be formulated and implemented through more sustained appropriations. Compared with ICHNR, USGNRP would have a renewed and clear mandate around improved coordination and harmonization, with explicit requirements for programmatic review, strategic planning, annual reporting, fiscal coordination on new initiatives, quadrennial assessments submitted to the President, and international research and cooperation. Like ONDFN, USGNRP activities would more efficiently and effectively identify topics that resonate across multiple departments and agencies with significant population impact and feasibility, while advancing emerging scientific opportunities and discoveries. Also like ONDFN, a strategic planning process would create transparency and accountability, including tasks of identifying and monitoring budgets and metrics of success.

ICHNR subcommittees could be transitioned to Interagency Working Groups to effectively and efficiently foster cross-department and cross-agency actions. As one example, a new DGA Interagency Working Group would have a stronger charge and dedicated staff to address new research needs identified by the latest DGAC. Like USGCRP, the participating USGNRP departments and agencies would utilize a National Coordination Office to help produce high-level and informative reports (298). USGNRP would also intersect with other high-level coordinating structures, such as USGCRP's Interagency Working Group on Climate Change and Health, to enable effective and rapid responses to acute threats such as COVID-19, other pandemics, or other future challenges.

Disadvantages. If based on the USGCRP appropriations model, USGCRP would be funded by a legislative mandate for contributions by participating members (rather than any new appropriations), so its budget would vary with the size and consistency of commitment of participating departments or agencies to its research areas of interest. Ideally, Congress would also authorize and appropriate some core funding for USGNRP, although no new, dedicated funding has emerged for USGCRP thus far. Also, significant staffing in the National Coordination Office would be temporary ("detailed") personnel from participating members, which could reduce continuity.

Path forward. USGNRP could be established by a Presidential Initiative, without legislative action. For longer-term success, Congress could later codify USGNRP into law (296). Alternatively, Congress could directly establish USGNRP (e.g., in place of ICHNR). In any of these cases, separate Congressional appropriations are not needed but would be ideal.

New Associate Director for Nutrition Science within the OSTP.

A new OSTP Associate Director for Nutrition Science would be a non–cabinet-level position, President-appointed and Senate-confirmed, who would serve as the President's advisor on issues related to nutrition research (**Supplemental Figure 5**). OSTP, established by Congress in 1976, has a broad mandate "to provide, within the Executive Office of the President, advice on the scientific, engineering, and technological aspects of issues that require attention at the highest level of Government" (Public Law 94–282). OSTP advises the President on science and technology topics related to domestic and international affairs, leads interagency efforts to develop and implement sound science and technology policies and budgets, and works with the private sector, state and local governments, science and academic communities, and other nations (299). In addition to the Director, Congress provides the President the authority to appoint up to 4 Associate Directors, subject to Senate confirmation. The statute provides great flexibility to the President with respect to corresponding areas of focus, expertise, and responsibility. Under President George W Bush, there were 2 Associate Directors—one focused on science and the other on technology—each with a Deputy Director. The Clinton Administration had 4 Associate Directors, focused on science, technology, environment, and national security and international affairs. President Obama's 4 Associate Directors focused on similar areas, with additional joint appointments of OSTP staff to the National Economic Council, National Security Council (NSC), Domestic Policy Council (DPC), and White House Office of Management and Budget (OMB) (300). President Trump's OSTP Director, confirmed in January 2019, has expressed interest in military readiness and national security, communication networks, energy and environmental leadership, health and bioeconomic innovation, and space exploration, among other areas (301). President Trump has appointed only 1 Associate Director, confirmed in August 2019, who also serves as the US Chief Technology Officer (302).

Prior OSTPs have had advisors on nutrition and, at the highest level, an Assistant Director of Nutrition in 2014–2015. However, OSTP has never had an Associate Director of Nutrition Science. Modeled after other Associate Directors, the Associate Director for Nutrition Science would provide high-level leadership to leverage and translate federal and nonfederal nutrition science

efforts, identify and help develop more coordinated and innovative nutrition research initiatives, and advise the President on corresponding national and international issues.

Advantages. OSTP has a long history of identifying and elevating science and technology opportunities for the President to help shape policy, programmatic, and resource allocation decisions. OSTP advises the OMB on research and development programs for annual White House budgetary requests. For example, OSTP support was instrumental to the doubling of the NIH's budget between 1998 and 2003 (303). OSTP can lead important coordination activities and reports among different federal departments and agencies as well as external stakeholders (304). An Associate Director of Nutrition Science provides a key leader to the White House to improve coordination, communication, and strategic planning around key priority areas in nutrition science. The Associate Director would also work closely with and elevate the communication and impact of individual federal departments and agencies and the ICHNR. The Associate Director can hire advisors, special assistants, or White House fellows to deepen expertise and impact and can lead efforts to create new collaborations with the private sector, state and local governments, academic communities, and other countries. Legislative action is not required; the President can simply assign 1 of the 4 allocated Associate Director slots.

Disadvantages. OSTP positions and areas of focus can dramatically change across administrations, greatly diminishing continuity and long-term effectiveness. OSTP staffing is often small, transient, and reliant on temporary ("detailed") staff from relevant departments and agencies. Success of this approach would be highly dependent on the skills and interests of the new Associate Director, rather than any concrete or consistent structure or process for strengthening federal nutrition research through increased coordination, funding, and alignment. OSTP initiatives may not align with focus or levels of research funding.

Path forward. A President can appoint an Associate Director for Nutrition Science, with Senate confirmation. Congress can also recommend a specific Associate Director focus, although recent recommendations were not successful [e.g., the 110th Congress recommended an Associate Director for Earth Science and Applications (Senate 1745), and the 111th Congress recommended an Associate Director and Coordinator for Societal Dimensions of Nanotechnology (House of Representatives 5116)] (299).

New US Task Force on Federal Nutrition Research.

A new US Task Force on Federal Nutrition Research would be charged with improving coordination and integration of federal nutrition research—for example, modeled after other timely US task forces such as on Combating Antibiotic-Resistant Bacteria (305); on Veteran Wellness, Empowerment, and Suicide Prevention (306); or on Combating Drug Addiction and the Opioid Crisis (307). As an example, in 2013, CDC, G7, and WHO each released reports or statements on the importance of dedicated prevention and infection-control efforts for antibiotic-resistant bacteria (305, 308, 309). In 2014, a Presidential Executive Order established combating antibiotic-resistant bacteria as a federal priority and created a new high-level task force (310). This Task Force for Combating Antibiotic-Resistant Bacteria was co-chaired by the Secretaries of HHS, USDA, and DoD, with representatives from Departments of State, DoJ, VA, and DHS and the EPA, USAID, OMB, DPC, NSC, OSTP, and NSF. Its functions included developing a 5-y National Action Plan and reporting to the President on the plan's progress. In addition, a Presidential Advisory Council on Combating Antibiotic-Resistant Bacteria composed of up to 30 members, appointed or designated by the co-chairs, was required to help advise the task force, culminating in a report to the President with recommended actions (311). The resulting National Action Plan, put forward in 2015, continues to guide federal actions toward a coordinated response to this pressing public health issue, directing efforts, personnel, and funding of participating departments and agencies toward a common critical agenda (312).

Modeled on that successful task force, the leadership, members, and general functions of a Task Force on Federal Nutrition Research would develop and report to the President on a major new National Action Plan for accelerating and strengthening nutrition discoveries (**Supplemental Figure 6**). Co-chairs could include HHS, USDA, and DoD (and perhaps VA) Secretaries, with additional broad representation from other diverse departments and agencies. A complementary Presidential Advisory Council on Nutrition Research would include expert members appointed by the co-chairs to advise the task force and provide a report of recommended actions to the President. This task force could also work well with ONDFN and/or the Associate Director of Nutrition Sciences in the OSTP.

Advantages. This is a tested, successful model on an area of science with some similarities, including multiple relevant federal departments and agencies and a need for international collaboration (313). The Presidential Executive Order would appropriately elevate the prioritization of nutrition research, create a concrete action plan, and include reporting on progress. The task force would benefit from cross-governmental cabinet-level leadership and include diverse relevant departments and agencies. The high-level Advisory Council provides a formal mechanism to leverage external expertise and input. These elements would together strengthen coordination and communication of existing important research efforts toward the highest impact agenda. Task force activities and reporting would help inform and amplify research budgets directed to participating departments and agencies. This approach does not require legislation.

Disadvantages. Despite its successes, no new funding was provided nor has emerged for the Task Force on Combating Antibiotic-Resistant Bacteria. That task force also has not developed any coordinated budget initiatives to date. A Presidential Executive Order remains in effect only until revoked, although it can endure across administrations (e.g., the Task Force for Combating Antibiotic-Resistant Bacteria has remained in place). A task force would likely have a defined scope over a set time period, and not provide sustained leadership and coordination into the future.

Path forward. The President can issue an Executive Order to establish nutrition research as a priority and create a US Task Force on Federal Nutrition Research. The President can also direct the heads of OSTP, DPC, and NSC to revise ICHNR coordination structure to more closely follow the Task Force model. Congress could also initiate such a task force by inquiring with the Executive Office of the President or with the relevant department and agency leadership about updating ICHNR or a potential new Presidential Executive Order or directive around nutrition research coordination. Congress could also revise the charge, structure, and funding of ICHNR via legislation to create appropriate activities consistent with such a task force.

Other new cross-governmental options.

- At the cabinet level, the Joint Chiefs of Staff could be called upon to focus on necessary nutrition research to address escalating diet-related health burdens on military readiness and national security (25, 86, 92, 314–318), leading coordinated efforts across DoD, other ICHNR members, and the National Collaborative on Childhood Obesity Research (**Supplemental Text 2**, **Supplemental Figure 7**).
- Congress could amend the National Nutrition Monitoring and Related Research Act of 1990 (Public Law 101–445) to authorize and appropriate a specific funding stream for the DGAs, DRIs, and associated monitoring and surveillance processes.
- HHS could mobilize existing or new positions within the Office of the Assistant Secretary of Health (e.g., a new HHS Office of Nutrition, modeled after the HHS Office of Women's Health or Office of Infectious Disease and HIV/AIDS Policy) to coordinate nutrition research needs and opportunities within and outside HHS.
- An ongoing GAO evaluation of federal policies and activities in relation to diet-related diseases and their economic burdens (319) may provide additional recommendations for increased coordination of nutrition research.
- Congress could authorize and appropriate funds for NASEM to assess the gaps and options to strengthen and coordinate federal nutrition research to address escalating diet-related health burdens and related economic, equity, national security, and sustainability challenges (320).
- Congress could appoint a global health coordinator to lead a new interagency council that reaffirms domestic and global health as a core national security interest. The coordinator and council would be charged with developing strategic plans to detect and prevent acute and chronic health threats, such as new infectious pandemics. Such a focus should incorporate the critical role of food and nutrition in population health and resilience, including against infectious diseases, and appropriate and coordinate the necessary activities for relevant research.

Identified NIH strategies for strengthening national nutrition research

As the nation's largest funder of research, NIH is one essential (although not exclusive) home for increased authority, coordination, and funding for nutrition science (110). Any new NIH strategy must leverage and amplify, not replace or compete with, existing extramural and intramural nutrition research efforts across the 27 current NIH institutes, centers, or offices or with existing nutrition research across other federal departments and agencies. Key identified strategies are summarized in **Table 4** and reviewed below.

New National Institute of Nutrition.

A new NIH National Institute of Nutrition (NIN) would be additive to the 27 current institutes and centers leading research within NIH (**Supplemental Figure 8**). NIN would be a crucial new asset for NIH to accomplish its mission "to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability" (321). NIN would be tasked with leading innovative, cross-cutting, and foundational research on nutrition and health, including intramural and extramural programs and training and outreach activities. Under the leadership of the NIN Director, NIN would help guide strategic planning, coordination, and review of nutrition research across NIH and with other federal departments and agencies. This would increase harmonization, collaboration, and leveraging of all nutrition-related research programs across NIH institutes, centers and offices. NIN priority areas and funding should be coordinated with, additive to, and synergistic with existing NIH nutrition research efforts, such as within NIDDK, NHLBI, and NCI, among others, as well as with USDA, CDC, FDA, DoD, VHA, and NASA, among others. Rather than "siloing" nutrition research, NIN would help craft strategies and focus areas that span across, support, and/or are not covered by specific interest areas of other federal nutrition research efforts. A new NIH National Advisory Council on Nutrition Research—comprising research experts, health professionals, and community members—would advise the HHS Secretary, NIH Director, and NIN Director on matters related to the NIN's mission.

NIN would expand the knowledge base of research on diet-related illnesses and their intersections with other fields through strategic planning, coordination, and evaluation of NIH nutrition research and through conduct and support of research in nutrition science and related areas. Relevant cross-cutting areas of focus could include many priority areas from genetic, molecular, and biological science to clinical, behavioral, and translational research, as well as research on health systems, workforce development, and health equity (Table 2). NIN's efforts would support, expand, and amplify key science relevant to other NIH institutes, centers, and offices, such as on nutrition and diabetes, obesity, cardiovascular disease, cancer, brain health, minority health and disparities, child health, and more. Within NIH, NIN would represent a natural authority and partner to support and coordinate cross-cutting intramural research that complements existing nutrition research portfolios across NIH. NIN would also promote and support the training of a diverse 21st century nutrition science workforce, including in cross-disciplinary priority areas like quantitative methods, personalization, and technology. Given NIH's roles in supporting training of health care professionals, NIN would also guide and support innovative programs to build a cadre of well-trained health professionals for

TABLE 4 Key strategies within the NIH for strengthening and accelerating national nutrition research[1]

Option	Description	Advantages	Disadvantages	Paths forward
New National Institute of Nutrition (NIN)[2]	• Leads research, coordination, training, outreach on foundational and cross-cutting topics in nutrition and health • Additive focus areas and funding to existing NIH and other federal nutrition research efforts • Harmonizes and leverages other nutrition and related research at NIH and other agencies and departments • Strong partner to inform, collaborate on, and help address joint research needs of other departments and agencies, e.g., USDA, FDA, CDC, DoD, VA, USAID, and CMS • Promotes and supports training of a diverse 21st century nutrition research workforce • Guides and supports training of health care professionals for clinical care and basic and translational science in nutrition • Translates and disseminates sound nutrition science findings to the public • Fosters innovative external collaborations and partnerships	• Strong leadership, robust infrastructure, and investment • Can better address nutrition science that is cross-cutting rather than disease specific • Includes extramural and intramural research, training, and outreach activities • A long-term structure, leading to unanticipated positive returns, outlasting shorter-term options, and evolving appropriately with changing science and needs of the US population • Meaningful external advisory mechanism to solicit diverse relevant insights and input • Strong return on investment, in line with or exceeding other NIH research investments	• Requires new, additive appropriations to prevent reductions in any ongoing NIH or other federal nutrition research • Could increase silo-ing of nutrition research • Would need to navigate potentially entrenched cultures and perspectives around NIN nutrition research • Without new appropriations, could increase competition for resources	• Congress establishes a new NIN by statute, with dedicated appropriations and updating the current cap on the number of NIH institutes and centers • Congressional inquiry and/or appropriations could explore the current status of federal nutrition research and potential options including an NIN

(*Continued*)

TABLE 4 (*Continued*)

Option	Description	Advantages	Disadvantages	Paths forward
New NIH Office for Nutrition Research	• Restores the NIDDK Office of Nutrition Research back into the NIH Office of the Director (within the Division of Program Coordination, Planning, and Strategic Initiatives) • Modeled after the NIH Office of Disease Prevention (ODP), Office of Dietary Supplements (ODS), or Office of Behavioral and Social Sciences Research (OBSSR) • Would lead efforts to build and coordinate new collaborative relationships and synergies within NIH, with other federal agencies and departments, and with external stakeholders including public-private partnerships to drive nutrition research and innovation • Plan and coordinate trans-NIH nutrition research initiatives • Lead cooperative efforts to identify and stimulate priority areas of science, provide guidance on rigorous methodology, offer trainings, and increase the impact, visibility, and dissemination of findings • Director of the NIH Office of Nutrition Research would also serve as the Associate Director of Nutrition Research	• Legislation is not required • Elevates the leadership, staffing, resources, and capacities of this important area within and outside NIH • Reestablishes close communication and coordination with the NIH Director and the other divisions and offices within the NIH Office of the Director • Increases capacity and expertise for dissemination of sound nutrition science • Can engage strong external advisory mechanisms • Some dedicated funding to stimulate research across NIH • Not viewed as serving only one institute • Ability to transition to an NIH center and/or institute over time	• Size and resources of such an office remain relatively limited for substantially needed strategic planning, cross-governmental collaboration, public communication, assistance with the DGAs, DRIs, and national monitoring and surveillance, food and nutrition regulatory activities, and external partnerships • Insufficient independent funding to stimulate major extramural or intramural research • Inadequate authority and resources to support new national training of scientists and health care professionals • Budgets, staff sizes, and influence can vary widely between offices and fluctuate over time	• NIH Director has discretion to restore this office into the NIH Office of the Director • Congress can authorize (ideally with new appropriations) the creation of this office within the NIH Office of the Director

(*Continued*)

TABLE 4 (*Continued*)

Option	Description	Advantages	Disadvantages	Paths forward
New Trans-NIH Initiative(s) in Nutrition Research	• An initiative across multiple NIH institutes and centers around a specific focused priority research topic • Modeled after several examples such as the BRAIN Initiative, "All of Us" Research Program, or the NIH Human Microbiome Project • Can be supported by dedicated staff within NIH and other federal working groups • Dedicated funding to support intramural and extramural research, training, and technology development • Can help create new or enhanced public–private partnerships	• Legislation is not required • Helps galvanize NIH around a key topic • Often preceded by a comprehensive and separately useful review of relevant leadership, staffing, funding, external advisory mechanisms, and collaborative approaches available across NIH • Brings new strategic planning, workgroups, funding opportunities, training, and technology development • Valuable when combined with other NIH options, above	• Only covers one focused topic, while needs and opportunities across nutrition research are broad and complex • Unlikely to provide the sustained leadership, coordination, and resources to grasp the critical science gaps and opportunities • Generally time-limited and not sustained	• Can be established by the NIH Office of the Director with support from the NIH Common Fund • Can be established by Congressional authorization and appropriations

[1]These strategies include key organizational structures successfully used within NIH (322). Importantly, these different options are not mutually exclusive, but can be implemented in combination to create synergies and leverage complementary strengths. CMS, Centers for Medicare and Medicaid Services; DGAs, *Dietary Guidelines for Americans*; DoD, Department of Defense; USAID, US Agency for International Development; VA, Department of Veterans Affairs.

[2]A new NIH National Center for Nutrition Research (NCNR) could also be proposed, broadly similar to the proposed NIN but on a smaller scale—for example, modeled after the path of the Office of Research on Minority Health (ORMH) within the NIH Office of the Director (Public Law 103–43) that led to the National Center on Minority Health and Health Disparities (NCMHD) (Public Law 106–525) that led to the National Institute on Minority Health and Health Disparities (NIMHD) (Public Law 111–148) (see Supplemental Text 3).

both clinical care and basic and translational science in nutrition (269, 323).

NIN would provide required leadership, staff, expertise, and resources to build meaningful partnerships on nutrition-related activities and research priorities of other federal departments and agencies, in particular USDA as well as FDA, CDC, DoD, VA, USAID, and CMS, among others. For example, this role could include development of joint requests with USDA for applications investigating the interlinkages between food, nutrition, health, and agricultural practices. NIN would support the efforts of HHS ODPHP in the USDA–HHS partnership to review evidence and, importantly, address new scientific needs for the DGAs. NIN would similarly support collaborative new science to inform the DRIs, FDA food safety and regulatory activities, USDA nutrition assistance programs, CDC surveillance and public health activities, USAID priorities, and DoD and VA research needs for US active-duty forces (including enhanced human performance and military readiness), military families, and veterans. NIN would inform and support CMS and CMMI efforts, such as "Food is Medicine" interventions to reduce diet-related illness and associated health care costs (268, 324, 325). Such joint initiatives will have the greatest impact if nutrition research at these other departments and agencies were simultaneously strengthened with new investments. NIN would also lead and have the required staff capacity to engage meaningfully in public–private partnerships and with nonprofit organizations and international entities such as the WHO and World Bank.

Advantages. NIN would add strong authority, infrastructure, investment, and external advisory mechanisms for nutrition research to the nation's largest funder of science. NIN would require a Federal Advisory Committee (Council) and would have a budget and funding authority. NIN would allow NIH to better address nutrition science that is cross-cutting rather than disease-specific, both across institutes, centers, and offices within NIH and with other federal departments and agencies. For example, the NIN would be instrumental in implementing and achieving the goals of the new 2020–2030 Strategic Plan for NIH Nutrition Research (129). As a long-term structure, NIN's activities and benefits would provide both expected and unexpected returns over many decades, outlasting shorter-term options such as cross-agency initiatives and changing priorities of individual administrations, and evolving appropriately with changes in science, food systems, nutritional needs, and disease conditions of the US public. A new institute could help maintain the strength of NIH focus on laboratory and clinical research in nutrition while, at the same time, facilitating expansion to research efforts to other translational priorities across NIH and across other federal departments and agencies. As has been seen with NIH research overall, NIN's coordinated leadership, structure, and capacity would likely provide a strong ROI to the US economy. The combination of NIN plus a new cross-governmental approach (Table 3) would provide a powerful strategy to address the scope and scale of the challenges and opportunities we face as a nation.

Disadvantages. The addition of a new institute would require legislative action to increase the current limit of 27 NIH institutes and centers (Public Law 109–482) and provide additive new appropriations to prevent reductions in any ongoing NIH or other federal nutrition research. NIN could increase silo-ing of nutrition research or divestment in nutrition research from other parts of NIH, which has historically been and should remain a component of almost all NIH institutes, offices, and centers. Even with a remit to coordinate and complement existing efforts, a new institute would need to navigate potentially entrenched cultures and perspectives around the "home" of certain areas of research. Congressional appropriations for expanded nutrition research funding within and outside NIH would be needed to prevent increased competition for resources.

Path forward. Congress can authorize the establishment of NIN, updating the cap (Public Law 109–482) on the total number of NIH institutes and centers and providing new, additive appropriations to NIH. As an intermediary step, Congress could submit an inquiry to appropriate federal departments and agencies, host hearings, as well as appropriate funds, to explore the current status of federal nutrition research and potential options including the NIN.

New National Center for Nutrition Research.

As a smaller model than a new institute, a new NIH National Center for Nutrition Research (NCNR) could be created, representing a 28th institute or center at NIH that would be broadly similar to a new NIN, although with less stature, staff, and funding (**Supplemental Text 3**). The NCNR could aim to accomplish many of the same goals as an NIN, on a lesser scale. Advantages, disadvantages, and the path forward for NCNR are likewise similar, on a reduced scale, to NIN. Long term, the NCNR could further evolve into an institute, as has happened to other centers at NIH. However, if a research area is of sufficient national priority that it may transition into an institute within a decade or less, then starting as a center can be inefficient, compared with directly creating an institute. For example, both the National Institute of Minority Health and Health Disparities (NIMHD) and National Institute of Nursing Research (NINR) were founded as centers but transitioned into institutes within $\leq$10 y (Public Laws 111–148, 99–158, 103–43).

New NIH ONR within the NIH Office of the Director.

This option would return ONR to the NIH Office of the Director (**Supplemental Figure 9**) (326), the central entity for setting NIH policy and planning and for managing and coordinating NIH programs and activities (327). Multiple offices and divisions within the NIH Office of the Director function together to identify opportunities and needs across the agency (328). The NIH ONR can be modeled after other Congressionally mandated offices within the NIH Office of the Director (see "Path forward" below). Each of these lead and coordinate trans-NIH efforts, guided by an Office director, dedicated expert staff (ranging from 15 to 30 full-time employees), and specific budgetary resources. Like the NIH Office of Disease Prevention Director who also serves as the Associate Director for Prevention (Public Law 99–158), the Director of the NIH ONR would also serve as the Associate Director for Nutrition Research.

The NIH ONR would lead efforts to build and coordinate new collaborative relationships and synergies within the NIH, with

other federal departments and agencies, and with external stakeholders including public–private partnerships to drive nutrition research and innovation. The NIH ONR would lead cooperative efforts to identify and stimulate priority areas of science, provide guidance on rigorous methodology, offer trainings, and increase the impact, visibility, and dissemination of findings. The new office would plan and coordinate relevant trans-NIH initiatives (see below), such as supported by the NIH Common Fund, a "venture" fund within the NIH Office of the Director, which aims to propel high-risk, high-reward research to speed scientific discovery and translation to improve health at a faster pace (329). The new office would develop approaches and resources to support analyses and reporting of nutrition research portfolios across NIH.

Advantages. Restoring the ONR into the NIH Office of the Director would elevate the leadership, staffing, resources, and capacities of this important area within and outside NIH. This structure would reestablish close communication and coordination with the NIH Director, other divisions and offices within the NIH Office of the Director, and the nutrition activities across all the NIH institutes and centers. This is particularly important for identification and prioritization of concrete, timely research focus areas, given the breadth of areas and topics touched by nutrition. This office would have some dedicated funds to help stimulate priority research across NIH and encourage NIH institutes, centers, and other offices to direct or pool their funds toward common priority areas and would not be dependent on or viewed as serving any single institute. This office could help stimulate new, flexible appropriations for the NIH Office of the Director to focus broadly on nutrition priority areas, outside the Common Fund per se.

In addition to research strategy and harmonization, the new office director and staff (including communications specialists, present in other similar NIH Office of the Director Offices) would increase capacity and expertise for dissemination of nutrition science to the public and other stakeholders. This office could engage strong external advisory mechanisms, strengthening input from other federal departments and agencies, academic institutions, advocacy groups, state and local governments, and community members. Based on Congressional prioritization of new national research areas, such an office can transition into a center (e.g., National Center for Complementary and Integrative Health; Public Laws 103–42, 105–277, 113–235) or an institute (e.g., NINR, Public Law 103–43; NIMHD, Public Laws 103–43, 106–525, 111–148).

Disadvantages. The size and resources of such an office would remain limited to coordinating and developing nutrition strategy across all NIH institutes, centers, and offices, inform and collaborate with other federal departments and agencies engaged in nutrition-relevant research and programming, assist with communication to the public, work with ODPHP in the USDA–HHS partnership to develop the DGAs, and meaningfully engage in public–private or other external partnerships. Such an office does not generally have sufficient independent funding to promote major extramural or intramural science. Such an office does not have sufficient authority or resources to support national training of new scientists and health care professionals in nutrition. An office's budget, staff size, and influence can vary widely across offices and over time depending on other NIH priorities.

Path forward. The NIH Director has discretion to restore this office into the NIH Office of the Director. Congress can also pass legislation to create a new Office of Nutrition Research within the NIH Office of the Director, similar to other Congressionally mandated offices such as the NIH Office of AIDS Research (Public Law 103–43), Office of Research on Women's Health (Public Law 103–340), Office of Behavioral and Social Sciences Research (330) (Public Law 103–43), Office of Disease Prevention (331) (Public Law 99–158), and Office of Dietary Supplements (332) (Public Law 103–417).

New trans-NIH initiative(s) in nutrition research.

Trans-NIH initiatives are efforts to promote collaborative research across NIH in a particular area of science. These initiatives can originate from the NIH Director; NIH institutes, centers, or offices; or Congress. Some of these initiatives engage with external stakeholders such as businesses and nonprofit foundations. The funding, leadership, and structures for trans-NIH initiatives tend to vary. Generally, trans-NIH programs utilize the same mechanisms of grant funding that NIH currently offers: research grants (R series), career development awards (K series), research training and fellowships (T & F series), program project/center grants (P series), and resource grants (various series) (333). NIH currently supports a variety of broad-reaching programs that are trans-NIH in nature; examples include Biomedical Information Science and Technology Institute (BISTI), NIH Blueprint for Neuroscience Research, Research Supplements to Promote Diversity in Health-Related Research, Administrative Supplements to Existing NIH Grants and Cooperative Agreements, New and Early Stage Investigators Policies, Genome-Wide Association Studies, NIH Common Fund, NIH Basic Behavioral and Social Science Research Opportunity Network (OppNet), Presidential Early Career Award for Scientists and Engineers, Stem Cell Information (PECASE), and the Trans-NIH Countermeasures Against Chemical Threats (CounterACT) program (333).

The NIH Common Fund has emerged as one approach to support trans-NIH programs and uses the same mechanisms of support. The NIH Common Fund is a specific component of the NIH budget and is managed by the Office of Strategic Coordination/Division of Program Coordination, Planning, and Strategic Coordination/Office of the NIH Director (329). Common Fund programs are short-term (usually ~5 y), goal-driven strategic investments that are "intended to change paradigms, develop innovative tools and technologies, and/or provide fundamental foundations for research that can be used by the broad biomedical research community" (329). Then, an NIH institute, center, or office or multiple institutes, centers, and offices must continue the support of these time-limited programs.

As one example, the NIH Human Microbiome Project was a trans-NIH initiative supported by the NIH Common Fund from 2007 to 2016 (334). This project aimed to expand science on the microbiome. Initially funded as an initiative of the NIH Roadmap for Biomedical Research, the NIH Human Microbiome Project was originally established as a 5-y project with a budget of $150 million (335). The project began with a "jumpstart"

phase in 2007 and a set of grants was funded in mid-2009 and additional demonstration project grants were awarded. These activities were supported by a Data Analysis and Coordination Center and a set of additional grants was awarded for developing new technologies, new software tools, and studying the ethical, legal, and social implications of this work. The grantees worked together in a highly cooperative consortium. Ultimately, this 10-y $215 million project spanned >20 of the NIH institutes, centers, and offices and resulted in a >40-fold increase in nonproject investment in microbiome research (336). That is, individual or multiple institutes, centers, and offices used program announcements or request for applications. Some of these funding mechanisms were supported by the Common Fund and others were additional commitments by the participating NIH institutes, centers, and offices from their own budgets. The Trans-NIH Microbiome Working Group established in 2012 provided a forum for coordinating NIH extramural research activities related to the human microbiome and continues to coordinate this work after the NIH Human Microbiome Project was completed. Notably, the NIH Human Microbiome Project identified several potential priority areas around food and the microbiome, but these topics have not yet been systematically pursued.

The Brain Research through Advancing Innovative Neurotechnologies (BRAIN) initiative is an example of a trans-NIH initiative (337), supported by staff within NIH and across federal working groups and providing funding for intramural and extramural research, training, and technology development. Between 2013 and 2019, this initiative supported >700 research projects totaling ~$1.3 billion through support across the NIH, including appropriations through the 21st Century Cures Act (Public Law 114–255) (337). The BRAIN initiative is managed by 10 NIH institutes and centers, with coordination at multiple levels. Extramural program staff and institute and center directors meet regularly to integrate strategic planning, management, and a BRAIN Multi-Council Working Group and Neuroethics Working Group provide further input on a variety of issues.

Another trans-NIH example is the All of US Research Program (Public Law 115–31), directly supported through annual appropriations from Congress ($1.5 billion over 10 y) (Public Law 115–31). This initiative, supported and overseen by NIH, arose from recommendations by the NIH's Precision Medicine Initiative Working Group of the Advisory Committee to the Director (338). The program staff are based in the NIH Office of the Director, with a Trans-NIH Liaisons Coordinating Team made up of scientific leaders from across NIH and has an external advisory panel.

A potential trans-NIH program in Precision Nutrition is being considered as an NIH Common Fund program for fiscal year 2021 (131, 339), and the NIH Director included Precision Nutrition in the NIH's congressional budget justification for fiscal year 2021 (131). A new Program Director in the NIDDK ONR was hired in 2020 to lead this initiative.

Advantages. Legislation is not required. A trans-NIH initiative can help galvanize NIH to develop a coordinated approach to a specific topic on nutrition and human health (e.g., see Table 2). Such an effort would generally be preceded by a careful—and separately useful—review of relevant NIH leadership, staffing, funding, external advisory mechanisms, and collaborative approaches available. A trans-NIH initiative brings new strategic planning, working groups, funding opportunities, training, and technology development. A trans-NIH initiative is complementary to other NIH and cross-governmental strategies to strengthen federal nutrition research. Such initiatives can also help build new or enhanced public–private partnerships.

Disadvantages. The needs and opportunities across nutrition research are broad and complex, and a new trans-NIH initiative would cover 1 focused topic, such as, if funded, precision nutrition. Addressing the science gaps and opportunities for nutrition—a leading cause of disease in the US—will require greater and more sustained authority, coordination, resources, and collaboration than provided by a single initiative, especially one only limited to precision nutrition. Trans-NIH initiatives are generally time-limited, difficult to sustain, and not easily communicated to a broad range of external stakeholders. The long-term success of such initiatives can be dependent on a single leading NIH institute, center, and/or office to commit to carry that area of work forward after the initial investments.

Path forward. The NIH Director could propose new trans-NIH budget initiatives for Congress to review; as noted earlier, Precision Nutrition is proposed in NIH's congressional budget justification for fiscal year 2021 (131). Congress could authorize and appropriate funds for this proposed initiative or put forth support for another or additional trans-NIH initiative(s) focused on ≥1 areas of nutrition research. NIH institutes, centers, and offices can develop and collectively support trans-NIH initiatives. External support through the private and nongovernment sectors can also be mobilized through public–private partnerships.

Identified USDA strategies for strengthening national nutrition research

In addition to NIH, the USDA is an important home for increased authority, coordination, and funding for nutrition science (110). As for NIH options, any new USDA strategy must leverage and strengthen, not supplant, existing extramural and intramural nutrition research efforts across USDA as well as other federal departments and agencies. Key identified strategies are discussed below. Each was considered as complementary, rather than mutually exclusive. Comparative advantages and disadvantages, executive and legislative considerations, and paths forward for these options should be the subject of future reports.

Increased investment in nutrition research across REE.

Declining appropriations for nutrition-relevant research and statistics at USDA, compounded by declining public investment in agrifood research and development, is limiting the nation's ability to fully understand and leverage the critical nexus between agriculture, food, and health (12, 146, 147). An emphasis on agricultural production research has created pressure on the USDA nutrition portfolio to respond to these growing research needs and opportunities with its limited budget. Strong Congressional appropriations for nutrition research across REE is critical to reestablish the US as the global leader in food and agricultural science and technology, which creates healthy and productive communities, families, and youth. A

renewed commitment to advancing and integrating nutrition into the overall crop, livestock, food manufacturing, food safety, natural resources, and climate research agendas has tremendous potential to improve economic growth, national security, competitiveness, sustainability, climate resilience, food security, and public health. Such investment would also maximize cross-governmental coordination and public–private partnerships with the greatest potential to accelerate progress in this complex nexus.

The USDA also implements major nutrition programs and thus must rely upon an integrated focus that connects nutrition research to policy and practice to improve the health of the public. To accomplish this integrated approach, each of the science mission areas at ARS, ERS, and NIFA must be at full capacity including sufficient staffing and resources. Nutrition research investment in ARS is essential for food-composition research and development, dietary surveys and food databases instrumental to national surveillance and scientific discovery, and the Human Nutrition Research Center network that pursues long-term, translation research priorities impractical to assess in short-term programs. NIFA complements ARS with competitive extramural funding vital to strengthening our nation's capacity to address opportunities related to diet, health, food safety, food security, and food science and technology. In addition, ERS provides invaluable food supply data, federal nutrition assistance program evaluations, and surveys on food insecurity and food acquisition and purchases.

Expanded USDA research to improve public guidance and education.

As detailed in earlier sections, the USDA CNPP plays a major role in the development of the DGAs, with far-reaching implications for many federal and nonfederal policies and programs such as the suite of 15 federal nutrition assistance programs, FDA regulatory policies, and clinical guidance for individuals from allied health professionals. Yet, the CNPP 2020 budget is only $6.6 million for nutrition evidence reviews, committee support, and DGA-related educational development. Further work is needed to provide consistent funding and staff to maintain and protect the scientific integrity for nutrition evidence systematic reviews; fundamental nutrition research, monitoring, and surveillance processes; and to develop, translate, and disseminate dietary guidance.

Other USDA investments in public guidance include SNAP-Ed, with $441 million in funding in 2020 (340). The benefits of this major effort could be further amplified by the creation of a robust SNAP-Ed infrastructure [e.g., similar to the USDA NIFA Gus Schumacher Nutrition Incentive Program (GusNIP) or SNAP Employment and Training] to support evaluation of novel educational interventions, including policy and systems changes, online purchasing strategies, and other environmental supports, using SNAP pilot authority (13). Similarly, expanded research on WIC Nutrition Education should address approaches to further strengthen this valuable program, such as new strategies for education on breastfeeding practices, food and beverage choices, sleep, and screen time, as well as novel information systems and technology including online, mobile, and telehealth options to deploy this guidance to WIC participants (13). Greater research on the USDA's State Nutrition Action Committee (SNAC) program—which helps states coordinate USDA food-assistance programs, Affordable Care Act community benefits, wellness, and other food and nutrition programs—and the USDA Farm to School Grant Program—which funds school districts, state and local agencies, Indian tribal organizations, agricultural producers, and nonprofit organizations to increase local foods served through child nutrition programs, teach children about food and agriculture through garden and classroom education, and develop schools' and farmers' capacities to participate in farm to school—would amplify benefits of these investments (13).

Innovative USDA research to strengthen benefits of nutrition assistance programs.

New research efforts supported by USDA, as well as NIH, are critical to develop the evidence base and collaborations to further augment the positive impacts of large federal investments in nutrition assistance (~$100 billion/y). Such research must, for example, delineate and address the tremendous increases in food insecurity, associated economic disruptions, and nutrition-related health disparities stemming from COVID-19. Now is the time to expand our understanding of the best approaches to increase the public health impacts of our suite of 15 federal nutrition assistance programs. This approach can include, for instance, new USDA-supported pilots and waivers to evaluate innovations that better support healthier eating in SNAP (e.g., healthy retail approaches, healthy food incentives combined with disincentives, online purchasing technologies) (13, 341). Further critical research needs include how USDA's nutrition assistance programs can be better integrated and coordinated with other federal and state programs, in particular Medicaid and Medicare, to improve diet-related health outcomes (13). These translational research investments will help address the varying geographic, contextual, and cultural needs of Americans and ensure the most effective outcomes from these essential federal programs.

Summary and Conclusions

This report identified stark national challenges in nutrition: diet-related illnesses, food insecurity, diet-related health disparities, health care costs for public and private payers, workforce productivity, military readiness, tremendous scientific debate and public confusion on a variety of critical topics, sustainability, and food system and population resilience to unexpected crises. Multiple federal departments and agencies are currently involved and investing in nutrition research and nutrition-related programs. However, as a share of total federal research expenditures, investments in nutrition research have been generally flat over the past 4 decades, despite the dramatic increase in diet-related illnesses such as obesity and type 2 diabetes and other identified diet-related challenges. Several current federal initiatives and collaborations aim to increase coordination of specific aspects of nutrition research and related activities across departments and agencies. Yet, the full potential of these efforts has not been realized, as documented by multiple governmental and other assessments since at least 1969, due to insufficient authority and funding.

The opportunities to be gained by greater coordination and investment in federal nutrition research are clear, with potential for large and rapid ROI. This report identified and described 2 priority strategies to strengthen federal nutrition research: *1*) a new authority for cross-governmental coordination of nutrition research and other nutrition-relevant policy and *2*) strengthened authority, investment, and coordination for nutrition research within NIH. These 2 strategies were found to be complementary and synergistic, each providing benefits that would be largest and most effective in concert. These options could potentially be a part of a multiyear strategy, initiated in part or whole (in some cases) by Congress or the President. Optimally, these options would garner full bipartisan support from the executive and legislative branches. Additional relevant priorities to strengthen federal nutrition research, particularly within USDA, were also recognized. Each of the identified options in this report would help create the new leadership, strategic planning, coordination, and investment the nation requires to address the challenges and grasp the opportunities we face.

We are indebted to a variety of federal agency staff and other stakeholders for their candid reflections of the past and present, as well as thorough assessments of potential strategies for moving forward. We are grateful to Dr. Sally Rockey and Dr. Yvonne Maddox for critical advisory comments and input and for input from Emily Broad Leib and Sarah Downer at the Center for Health Law and Policy Innovation at Harvard Law School. We are grateful for input from members of the Nutrition Action Alliance (NAA), a coalition of organizations working to advance federal nutrition research, nutrition education, and nutrition monitoring and surveillance, among other activities, which includes ASN, Academy of Nutrition and Dietetics, American Society for Parenteral and Enteral Nutrition, Association of Nutrition Departments and Programs, Institute of Food Technologists, National Board of Physician Nutrition Specialists, Society for Nutrition Education and Behavior, and The Obesity Society. This opportunity to review and provide feedback did not imply that the NAA nor any individual member organization has taken a specific policy position on every strategy option referenced in the paper. We thank Sylara Marie Cruz for outstanding management support.

The authors' responsibilities were as follows—SEF, CEW, PMC, VSH, and DM: were on the lead writing group of this paper; the remaining authors regularly reviewed drafts and provided substantive feedback during regular calls and rounds of reviews; and all authors: read and approved the final manuscript. PMC reports paid consultancies with the Indiana University School of Public Health at Bloomington, Purdue University Department of Nutrition Sciences, and the Friedman School of Nutrition Science and Policy at Tufts University. SEF reports paid consultancies with the Friedman School of Nutrition Science and Policy at Tufts University and various paid work with Healthy Eating Research, a national program of the Robert Wood Johnson Foundation. VSH reports paid consultancies with the Indiana University School of Public Health at Bloomington and the Friedman School of Nutrition Science and Policy at Tufts University. DM reports research funding from the NIH and the Gates Foundation; personal fees from GOED, Bunge, Indigo Agriculture, Motif FoodWorks, Amarin, Acasti Pharma, Cleveland Clinic Foundation, America's Test Kitchen, and Danone; participating on scientific advisory boards of start-up companies focused on innovations for health including Brightseed, DayTwo, Elysium Health, Filtricine, Foodome, HumanCo, and Tiny Organics; and chapter royalties from UpToDate, all outside the submitted work; as well as research funding from The Rockefeller Foundation. PJS reports grant/research support from the NIH; participating on scientific advisory and/or membership boards of Marabou Foundation, the National Academy of Sciences, Engineering, and Medicine, the ASN, and International Council on Amino Acid Science; and holding stock in TIAA, all outside the submitted work. CEW reports a paid consultancy with the World Wildlife Fund for their research on sustainable food systems under a grant from The Rockefeller Foundation, outside the submitted work with the Friedman School of Nutrition Science and Policy at Tufts University. The other authors report no conflicts of interest.

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