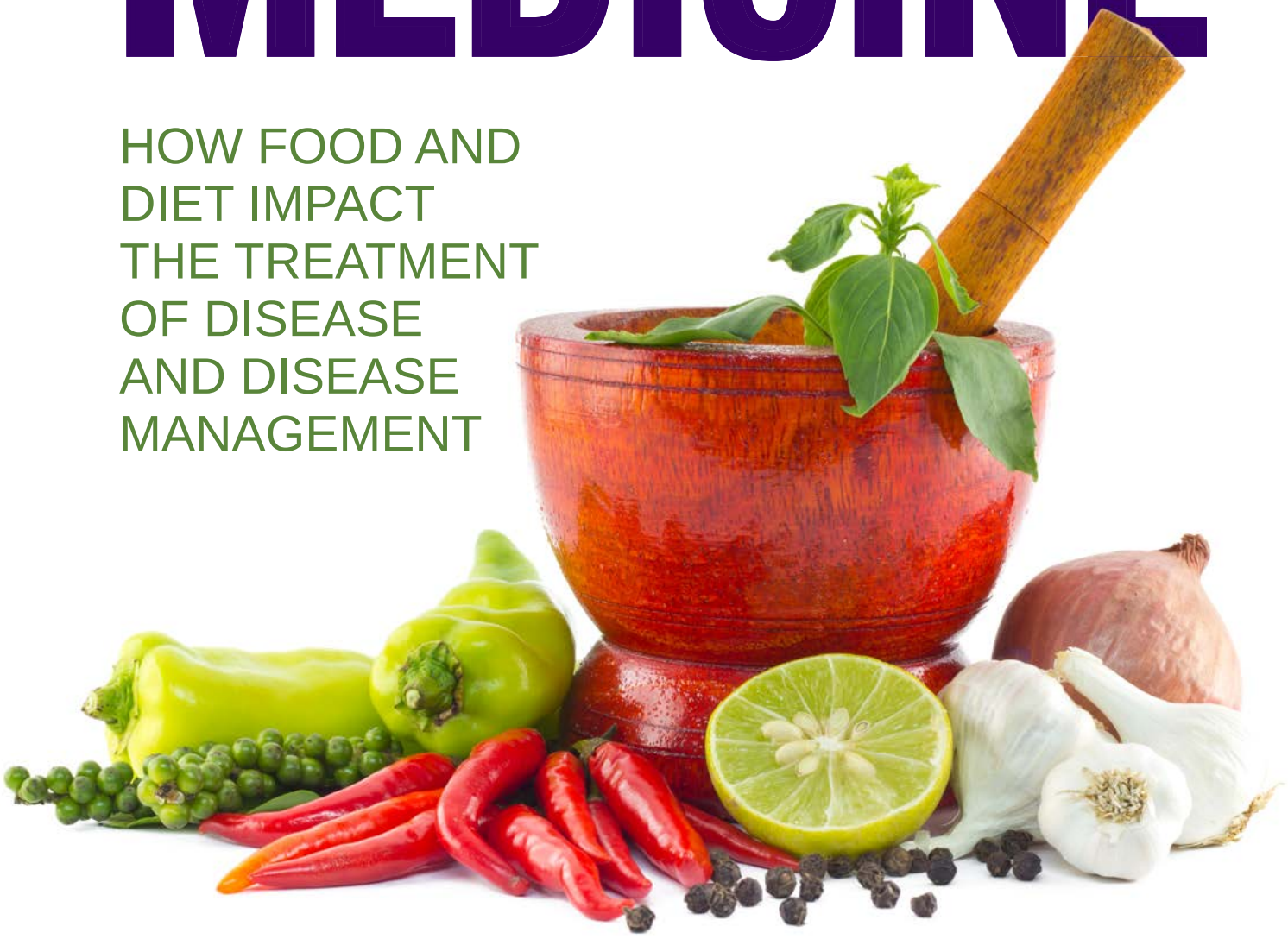
FOOD AS MEDICINE

HOW FOOD AND DIET IMPACT THE TREATMENT OF DISEASE AND DISEASE MANAGEMENT



CENTER FOR FOOD AS MEDICINE

HUNTER COLLEGE NEW YORK CITY FOOD POLICY CENTER

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Food as Medicine Resources and Research Guides

The Center for Food as Medicine (foodmedcenter.org) is a not-for-profit organization working to uncover the mysteries and myths surrounding food, nutrition, fitness and medicine with the goal of educating, engaging, inspiring and creating a catalyst for meaningful change in personal and community health and wellness. The Center combines journalism, scientific research and health literacy to synthesize complex health and medical information surrounding food and disease, and translates this information to readers searching for reliable, scientific information. The Center was founded by Charles Platkin, PhD, JD, MPH in 2021.

The Hunter College New York City Food Policy Center (nycfoodpolicy.org) develops intersectoral, innovative and evidence-based solutions to prevent diet-related diseases and promote food security in New York City and other urban centers. The Center works with policy makers, community organizations, advocates and the public to create healthier, more sustainable food environments and to use food to promote community and economic development. Through interdisciplinary research, policy analysis, evaluation and education, we leverage the expertise and passion of the students, faculty and staff of Hunter College. The Center aims to make New York City a model for smart, fair food policy.

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Introduction

Introduction

In July of 2021, famed chef Tom Colicchio made a decision to open a healthy restaurant in a children's hospital. According to the *Washington Post*, "Root & Sprig, [is] a new fast-casual concept that aims to give patients, families, doctors and other healthcare workers a better meal when they're at a hospital, whether working or recovering."[1] Colicchio's restaurant is one of the latest developments in the increasingly popular "food as medicine" movement, a philosophy arguing that the food we eat impacts our health by preventing and/or fighting disease.

There are a variety of key terms and phrases used to describe and discuss food as medicine, including but not limited to: food *is* medicine, culinary medicine, culinary nutrition, medically tailored meals, medically tailored groceries, medically tailored food packages, food for health, nutritious food referrals, prescription fruit and vegetable programs, using food for disease management, and community-level healthy food programs. There are a variety of definitions and phrases to describe the integration of food to prevent and or treat disease.

Using food for prevention and treatment of disease has a long history and documented efficacy.[2,3] In fact, evidence indicates that sustained dietary changes can be as effective as pharmacological interventions in treating certain diseases, especially in the early stages of the disease.[4,5] In some instances, a long-term, specific diet may be more effective than medication at mitigating, stabilizing, and reversing disease.[6,7,8,9,10] Additionally, using drug treatments in combination with a healthy tailored diet may be more impactful than drugs alone; there are a plethora of studies which demonstrate the extensive health benefits of food as medicine and indicate that the focus should not be on diet or medicine alone, but rather on diet and medicine.[11,12,13,14]

In an interview in the *Harvard Health Policy Review* about her research, Lisa Haushofer, MD, PhD, a senior research associate at the Institute for Biomedical Ethics and History of Medicine at the University of Zurich, discussed the boundaries between food and medicine, stating "one of the things I try to understand in my research is how nutrition came to be so marginalized in contemporary biomedicine and how instead it was absorbed increasingly by a nutritional consumer industry."[15]

Impact of Poor Diet on Health, Disease, and Health Care Costs

There is overwhelming evidence demonstrating the impact of food and diet on health, specifically among food-related diseases.[16,17,18,19,20] Whether or not a poor diet can cause damage to the body should no longer be debated, as evidence supports the potential causal relationships between dietary factors and diet-related diseases such as ischemic heart disease, diabetes, and certain cancers.[21,22,23,24,25,26,27] For example, researchers reporting in the journal *PLOS Medicine* found that a "[s]uboptimal diet of 10 dietary factors accounts for 18.2 percent of all ischemic heart disease, stroke, and type 2 diabetes costs in the US."[28] The ten factors these researchers studied were fruits, vegetables, nuts/seeds, whole grains, red meat, sugar-sweetened beverages, processed meat, polyunsaturated fatty acids, seafood omega-3, and sodium.[29] Unbalanced consumption habits of the aforementioned ten factors are estimated to cost Americans $50.4 billion in diet-related cardiometabolic disease expenses annually.[30]

There is also evidence showing that the chemical structures and composition of food can have a significant impact on individual and population health - sugar, oils, saturated fats, pesticides, and processed foods are known to pose a wide variety of health risks and diseases.[31] Further, the increasing availability of ultra-processed foods coincides with the rise of obesity, chronic illness, and other diet-related diseases.[32] According to data from the CDC in 2018, 42.8 percent of American adults over 60, nearly 45 percent of adults aged 44-59 years, and 40 percent of young adults (age 20-39) are obese.[33] Additionally, 60 percent of Americans have an underlying health condition: 121.5 million adults have cardiovascular disease and over 34 million have diagnosed type 2 diabetes. As of 2020, an additional 88 million American adults have prediabetes.[34,35,36]

These diet-related diseases consume a significant portion of medical costs. In 2017, the total estimated cost of diagnosed diabetes alone was $327 billion in medical costs and lost productivity.[37,38] Obesity costs the United States roughly $147 billion a year,[39] and heart disease and stroke together cost the health care system $214 billion per year and $138 billion in lost productivity in the workforce.[40] Estimates project that chronic diseases will cost more than $47 trillion in lost output between the years 2011 and 2030.[41] Additionally there is a significant socioeconomic disparity in health.[42] Studies have shown that lower socioeconomic status has been linked to disproportionate access to adequate health care among a variety of diseases.[43] Individuals of lower socioeconomic status have higher rates of cardiovascular disease, hypertension, arthritis, diabetes, and cancer.[44] With this increased rate of disease comes an increase in mortality, especially beginning at middle age.[45]

Poor diet has also been linked to increased morbidity and mortality across many diet-related diseases.[46] According to the Global Burden of Disease study published by the *Journal of the American Medical Association,* poor diet is the number-one risk factor associated with morbidity and mortality in the United States.[47] A comparative risk assessment published in *The Lancet* looked at the global burden of disease across 195 countries and found that in the year 2017, 11 million deaths and 255 million disability-adjusted life-years (DALYs) were attributable to dietary risk factors.[48] In fact, according to the researchers, high intake of sodium accounted for 3 million deaths and 70 million DALYs, low intake of whole grains accounted for 3 million deaths and 82 million DALYs, and low intake of fruits accounted for 2 million deaths and 65 million DALYs.[49]

Food for Preventive Health, Disease Treatment & Public Health

While diet has the potential to cause disease, it is also capable of building, maintaining, and restoring health.[50,51,52,53] Unprocessed whole foods, for example, provide nutrients the body needs to prevent and combat diseases and disorders that respond favorably to nutritional intervention.[54] A systematic review of existing research on U.S. dietary patterns published in the the *Journal of the American Medical Association* found evidence that nutrient-dense diets reduced patients' risk of dying from chronic disease. [55] The review, which assessed one randomized trial and 152 observational studies, concluded that diets rich in vegetables, fruits, lean proteins, nuts, legumes, and whole grains decreased mortality rates associated with cardiovascular disease, obesity, diabetes, and some cancers.[56] This decline in patient mortality was observed across the studies despite differences in approach and assessment methods.[57]

Recent research has also suggested that even relatively small dietary adjustments can help to reverse the increased mortality rates attributable to food-related diseases.[58,59] In an August 2021 study published by *Nature Food*, researchers reported that substituting 10 percent of the beef and processed meats in patients' diets for fruits, vegetables, legumes, nuts, and select seafood could increase their lifespans by 48 minutes per person per day.[60] Researchers arrived at this estimate by scoring foods according to 15 dietary risk factors for chronic disease and translating these scores into an assessment of the net minutes of healthy life gained or lost through consuming them.[61]

Reductions to the amount of added sugar in the American diet also show promise as means of improving and equalizing health care outcomes.[62] Research conducted on behalf of the American Heart Association and published in August 2021 suggests that achieving the packaged food and beverage sugar content targets set by the US National Salt and Sugar Reduction Initiative in 2018 could prevent almost half a million deaths from cardiovascular disease and around 750,000 diabetes cases.[63] These reductions in chronic disease would likely translate to a $160 billion reduction in health care costs over a 28.33 year period.[64] Achieving the targets is also anticipated to have the greatest impact on the health of individuals with lower income, as well as Black and Hispanic Americans, helping to reduce health disparities.[65]

Diet may also provide a solution when disease is present.[66] In fact, food interventions are effectively being used to prevent, manage, treat, and co-treat, a variety of disease states (e.g. Alzheimer's,[67,68,69] arthritis,[70,71] autism,[72,73,74,75,76] cancer,[77,78] cardiovascular disease,[79,80,81] celiac disease,[82] chronic kidney disease,[83,84] cirrhosis/ascites,[85,86,87,88] Crohn's,[89,90,91] depression,[92,93] diabetes,[94,95] digestive disorders,[96,97] eating disorders,[98,99] epilepsy,[100] food allergies/intolerances,[101,102,103] gastroesophageal reflux disease,[104,105,106] HIV/AIDS,[107,108] hypertension,[109,110,111] multiple sclerosis,[112,113,114,115] osteoporosis,[116,117,118,119] overweight/obesity,[120,121] and skin diseases[122,123,124]). [Note: Treatment of disease, using food, alone or in combination with other treatments, will be discussed in Part IV more extensively.]

Health care systems are increasingly being encouraged to use food as medicine interventions, such as medically-tailored meals[125] and food (i.e., fruit and vegetable) prescriptions,[126] as methods of achieving improved health outcomes in patients with diet-related chronic diseases.[127,128,129,130,131] For example, at NYU Langone's Perlmutter Cancer Center in New York City, cancer patients are receiving individually-tailored nutritious meals to help them tackle loss of appetite.[132] Addressing this issue is critical as malnourishment from not eating can lead to greater complications during cancer treatment.[133]

Additionally, related evidence is growing to support the impact of food-based government policies to improve public health. Researchers from a study published in the journal *Health Affairs* found that patients dually eligible for Medicare and Medicaid in a medically-tailored meal program had fewer emergency department visits and lower health-related costs.[134] Covering healthy meals under Medicare and Medicaid therefore could be an effective way to improve the health of those enrolled. (Approximately 80 million individuals in the United States have health coverage through Medicaid and the Children's Health Insurance Program [CHIP] in 2021 and approximately 61 million individuals have health coverage through Medicare.)[135,136]

Furthermore, various state governments have begun investing in food-related movements to improve the social and economic conditions that contribute to health.[137] For example, New York State passed a bill in 2019 that requires hospitals to provide plant-based meals at no extra cost to patients.[138] Jay Inslee, Governor of Washington State, signed an executive order in 2013 that requires state agencies provide "healthful food and beverages" in cafeterias, vending machines, catered meetings, and retail establishments.[139] On the federal level, the Agriculture Improvement Act (known as the Farm Bill) includes support and funding for produce prescription programs by way of the Gus Schumacher Nutrition Incentive Program.[140]

Synthesizing the Evidence to Drive Change

For change to occur in our food and health systems, and for food as medicine to be incorporated in our health care system and policies, diverse stakeholders must be engaged, including farmers, chefs, physicians and physician extenders, nutritionists, policymakers, elected officials, government staffers, community based organizations, public health advocates, academics, insurance companies, food companies, media, and patients.[141] However, meaningful progress towards impactful interventions and policies is limited by the accessibility of *evidence-based* information about the prevention and treatment of disease using food and or a combination of food and other treatments.

The focus of this report is to synthesize existing scholarship on food as medicine into a single, interdisciplinary resource. This report will serve as the basis for a shared understanding among scientists, medical professionals, policymakers, and other key stakeholders of how food can be used in the management and treatment of chronic disease and can lay the foundation for future study of food as a therapeutic.

The first section, “Part I: Food as Medicine - A Brief History,” highlights how food as medicine was practiced across ancient cultures, and its rise in popularity in modern society and popular culture. The second section, “Part II: Food as Medicine Challenges,” discusses critical challenges in the food ecosystem that limit the reach and impact of the food as medicine movement. The third section, “Part III: Food as Medicine - Interventions, Programs, Policies and Practices,” describes food as medicine interventions and spotlights successful programs and policies leveraging food as medicine philosophy. Lastly, the fourth section, “Part IV: Food as Medicine - Treating and Managing Disease,” summarizes the evidence of food as medicine to treat and manage specific diseases and conditions. This report concludes with a list of recommendations for readers who currently are or aim to be advocates for and key stakeholders in the food as medicine movement.

Part I

Food as Medicine: A Brief History

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Food as Medicine: A Brief History

As early as 300 BCE, humans were cultivating food crops for medicinal purposes.[142] Since that time, food as medicine and food as preventive medicine remained an integral component of many Eastern healing practices. Practitioners advised people how to live so that they would not become ill, although it was generally acknowledged that diet was powerless against epidemic diseases.[143,144]

Western cultures, however, have slowly broken away from using food as medicine.[145] In the 18th and 19th centuries, scientific investigation and innovation dominated Western understanding of medicine.[146] During that time, American medical education underwent notable advancements.[147] In 1745, the first formal course in human anatomy was established at the University of Pennsylvania, and in 1829, the first American textbook on pathology was published.[148,149] These innovations, among others, ultimately inspired a shift away from nutrition-based medicine towards allopathic medicine.[150] Allopathic medicine is defined by the National Cancer Institute as: "A system in which medical doctors and other healthcare professionals (such as nurses, pharmacists, and therapists) treat symptoms and diseases using drugs, radiation, or surgery. Also called biomedicine, conventional medicine, mainstream medicine, orthodox medicine, and Western medicine."[151]

However, the use of food as medicine is rooted in science and has been adopted and practiced by numerous cultures despite the fact that the history of food as medicine was largely ignored by academics until the 21st century.[152,153,154] Now, largely because of its increasing social media presence and online attention,[155,156] academic study of the history and use of food as medicine has begun to gain momentum, finding its place in journals, conferences, and programs of study.[157,158,159,160]

Food as Medicine in Ancient Cultures

Many ancient cultures shared a holistic belief that disease was caused by the improper flow of the body's vital energies.[161] Because ancient healers and physicians lacked much of the knowledge and technologies we use in medical practice today, their treatments were often reliant on food.[162,163] Most treatments used rituals, elixirs, herbs, and dietary practices to eliminate blockages and restore balance to the body,[164] while the risks and dangers of emerging, curative medicine were frequently as harmful as the illness itself (e.g., bloodletting, trepanation, tracheostomies).[165,166,167]

Traditional Chinese Medicine

The use of food as medicine in China may date back as far as the Neolithic period, when people sacrificed ale and meat to their ancestors in the hope of securing the spirits' protection from death and disease.[168] By the Qin dynasty (221-206 BCE), dieticians had emerged as one of the six categories of Chinese physicians.[169] Around this time, Chinese shamans and physicians began to record "Recipes For Nurturing Life" (*Yang sheng fang),* which, according to Stanford University's Encyclopedia of Philosophy, "consists of eighty-seven recipes, including food, drugs, and beverages, along with several sexual cultivation exercises."[170,171] Alongside the standard information on symptoms, diagnostics, and treatments, Chinese medical textbooks contained botanical field guides that gave extensive information about medicinal herbs.[172] Certain principles of Traditional Chinese Medicine are evident in many current views concerning diet and disease among Chinese people today,[173] such as the importance of a consistent, balanced diet composed of grains, vegetables, and fruit.[174]

One of the main ways Chinese physicians used herbs was to balance *qi (CHē)*. A fundamental concept in Chinese medicine, *qi* refers to a vital life energy that circulates through people and their environment.[175] According to practitioners of Traditional Chinese Medicine, *qi* flowed according to the complementary and opposed dynamics of *yin* and *yang*. People's health depended on having the right balance of *yin* and *yang* so that their *qi* would flow properly.[176,177] Among the "Recipes for Nurturing Life" were dietary methods for people to achieve the proper circulation of *qi* in their bodies.[178] Foods were categorized as promoting *yin* or *yang* and prescribed to the sick to reset this balance and eliminate disease. If patients showed symptoms of "greater yang disease," for example, including trouble breathing, fever, chills, and vomiting, they were prescribed a tea made with cinnamon, ginger, and various flowers, fruits, and spices.[179] The cinnamon was said to cure chills, and ginger calmed the vomiting, while peony and licorice reset the *yin* and boosted the body's defenses against the disease.[180] When looking at this prescription through a modern lens, it becomes clear why it was used. Cinnamon has anti-inflammatory properties to treat fever,[181] and studies have shown ginger to be effective against nausea.[182] In addition, both peony root and licorice have antioxidant properties.[183,184,185]

In addition to using food to treat individual patients, Traditional Chinese Medicine turned food into a tool for improving public health. When an epidemic swept through China during the Song dynasty (960-1279 CE) and had a particularly devastating impact on its poor,[186] Emperor Huizong (1082-1135 CE) responded by creating "Peace and Relief Hospitals" in rural provinces.[187] Each hospital had a kitchen and a pharmacy and treated patients with easy-to-consume prescriptions created from medicinal foods.[188] The success of these treatments prompted many physicians to found private pharmacies,[189] and as the number of pharmacies grew and the techniques they used to create medicine became more precise, food-based prescriptions grew to be among the most accessible and well-regarded forms of treating disease and solving public health crises in premodern China.[190]

Traditional Chinese Medicine is still practiced extensively today, and the National Institutes of Health's National Center for Complementary and Integrative Health (NCCIH) keeps information about the safety of various remedies available for people interested in using this method of addressing health problems.[191] Worldwide, an estimated 1.5 billion people use Chinese herbal medicine today, and the value of the Traditional Chinese Medicine industry is estimated to be about a third of the total pharmaceutical industry in China.[192] Furthermore, according to the WHO's 2019 Global Report on Traditional and Complementary Medicine, 100 member states formally acknowledged that Traditional Chinese Medicine was used by people in their country.[193]

The Cochrane Database of Systematic Reviews has compiled research on Traditional Chinese Medicine treatments for numerous diseases and conditions, and has found evidence that it might be effective in treating angina pectoris,[194] endometriosis,[195] high cholesterol,[196] irritable bowel syndrome,[197] menstrual cramps,[198] and more. However, almost 50 percent of Traditional Chinese Medicine reviews in the Cochrane Database were conducted without the involvement of a Traditional Chinese Medicine practitioner, the inclusion of whom likely would have improved the researchers' understanding of how practitioners determine individual treatment plans.[199] Additionally, the authors noted that the reviews related to Traditional Chinese Medicine "were not up-to-date according to Cochrane criteria, some reviews pooled the results of different herbal medicines and ignored the searching of Chinese databases."[200]

While there have been a plethora of clinical studies of the effectiveness of various Traditional Chinese Medicine practices, there is a lack of good quality evidence with high credibility.[201,202] Since Traditional Chinese Medicine is so popular today in China and beyond, effective integration of its therapeutic practices with evidence-based medicine could help patients find the most effective treatment plan for their lives and conditions.[203]

Food as Medicine in Ancient Greece

The Greek physician Hippocrates (460-375BCE)[204] and the physician and philosopher Galen (129-216 CE)[205] are often described as the forefathers of modern Western medicine.[206,207] There is little known about the life of Hippocrates beyond his status as one of the first medical researchers to attribute the body's health to diet and medicine rather than divinity and the gods.[208,209] There are about 60 surviving medical texts that bear his name, but scholars think that most of these works were not actually written by him.[210] Hundreds of years after Hippocrates came Galen, a Greek-born expatriate living in Rome who

Spotlight: Hippocrates and the Quote Representing of Food as Medicine

It is important to note that Ancient Greek physicians, including Hippocrates, did not confuse food and medicine.[211] Rather, food and diet were understood to contribute to a person's health, and the importance of nutritional intervention was well established.[212] Hippocrates is also often credited with the following impactful quote: "Let food be thy medicine and medicine be thy food," which is perhaps the most well-known quote attributed to the food as medicine movement.[213,214,215] While Hippocrates was a pioneer in developing evidence-based medicine (which included studying the effect of diet on health),[216] according to Diana Cárdenas, MD, PhD, associate editor of the journal Clinical Nutrition ESPEN and professor in the faculty of medicine at the Universidad El Bosque, Colombia, there is no evidence that Hippocrates made this statement.[217,218]

"[Hippocrates'] work was compiled either directly or indirectly through his disciples, so that the existing knowledge on Hippocrates' medicine consists of more than 60 texts known as The Hippocratic Corpus (Corpus Hippocraticum). This important text in the history of medicine expounds on the theory of diet."[219,220,221] In these texts, disease is attributed to natural causes, physiological imbalances, and poor diet.[222]

While Dr. Cárdenas believes the statement has had tremendous impact, she argues "the phrase 'let food be thy medicine and medicine be thy food,' a widespread phrase quoted by today's scientists, is nowhere to be seen [in the 60 medical texts know as Hippocratic Corpus (Corpus Hippocraticum)]. This literary creation is not only a misquotation but it also leads to an essential misconception: in the Hippocratic medicine, even if food was closely linked to health and disease, the concept of food was not confused with that of medicine."[223] Dietary intervention was considered one of the most important medical interventions that Hippocratic physicians could use to treat disease, but it was separate from medicine and surgical procedures.[224]

Nevertheless the quotation has appeared in numerous scholarly publications[225] and according to Dr. Cárdenas in the quote has been used:

- To explore the association between diet and health
- To highlight the medicinal properties of foods
- To emphasize the skeptical attitude of doctors towards nutrition
- To emphasize the antiquity of the "widely accepted for generations philosophy of medicinal power of foods"
- To highlight the lack of nutrition care in hospitals[226]

While the quote "Let food be thy medicine and medicine be thy food," may not have been directly mentioned in Hippocrates' 60 medical texts, there is the possibility that it was stated rather than written, nevertheless, the impact and meaning has been far reaching.

served as physician to the Roman emperor Marcus Aurelius.[227] Galen's works, which were built upon those of Hippocrates, supported physiological experimentation and a thorough understanding of anatomy.[228]

Hippocrates considered bodily factors known as "humors" in his treatment of patients.[229] The humors are four fluids—phlegm, blood, yellow bile, and black bile—that, according to Hippocrates, needed to be kept in balance in order to maintain health.[230] For example, an excess of black bile was thought to cause cancer.[231] Humoral theory remained popular well into the Elizabethan era of England and beyond.[232,233,234,235,236] Shakespeare used humoral theory in some of his plays, including *The Taming of the Shrew*[237] and *The Merchant of Venice*.[238] The balance (or imbalance) of the four humors was said to influence people's dispositions and characteristics,[239] and the attitudes of different characters in Shakespeare's plays were frequently attributed to their humors.[240,241] Only once people began to understand bacteria and viruses as major causes of disease did humoral medicine fall out of favor in the West.[242]

Dietetics was largely viewed as synonymous with internal medicine in ancient Greek medical practice.[243] It is important to note that to many ancient Greek scholars of medicine, the phrase *diaita* (roughly translated to "dietetics") refers to food, drink, and physical exercise.[244] In some cases, *diaita* also encompasses bathing and sexual activity.[245] In one of the Hippocratic texts, *On Diet*, dietetics is seen as directly influencing the body's internal temperature and moisture balance.[246] Certain foods were written about in Hippocrates's body of work as being heating, cooling, drying, or moistening. For example, if a Greek physician determined that a patient needed to "cool down," he might prescribe a regimen of specific "foodstuffs" and types of exercise to achieve this effect.[247]

Ancient Greek medicine has left a lasting legacy: physicians and health care professionals still must follow the principles of the Hippocratic Oath[248] and the caduceus (a rod with two intertwined snakes that was the symbol of the Greek god Hermes) has become a symbol for modern medicine.[249] English speakers still use humoral words like "melancholic" (black bile) and "sanguine" (blood) to describe people of different temperaments and characteristics.[250,251]

Ayurvedic Medicine in India

Ayurveda is an ancient form of medicine that has been practiced in India for more than 3,000 years.[252] According to the National Institutes of Health's National Center for Complementary and Integrative Health (NCCIH) overview of Ayurvedic medicine:

> The ancient Indian medical system, also known as Ayurveda, is based on ancient writings that rely on a 'natural' and holistic approach to physical and mental health. Ayurvedic medicine is one of the world's oldest medical systems and is still practiced today. Ayurvedic treatment combines products that are mainly derived from plants but may also include animal, metal, and mineral, along with diet, exercise, and lifestyle.[253]

The NCCIH also describes a few well designed studies and systematic research reviews demonstrating the effectiveness of Ayurvedic Medicine for conditions including knee osteoarthritis,[254] rheumatoid arthritis,[255,256] type 2 diabetes,[257] and ulcerative colitis.[258] [See Ayurvedic Medicine - Systematic Reviews/Reviews/Meta-analyses (PubMed) and Ayurvedic Medicine - Randomized Controlled Trials (PubMed)]

Ayurvedic practice has roots in two ancient Hindu schools of thought: *Vaisheshika*, a school of philosophy, and *Nyaya*, a school of logic.[283] *Vaisheshika* describes the observations that must be made about a patient's condition, and *Nyaya* teaches that practitioners of medicine should have extensive knowledge of a disease before treating a patient.[284] The healing practices taught by these Hindu schools of thought were later compiled into two texts, the *Charaka Samhita* and the *Sushruta Samhita*,[285] which are most frequently referred to by historians when studying Ayurvedic theory.[286]

Ayurvedic practitioners attribute the body's basic physiological functions to three *doshas* or energies (sometimes spelled *dosa*[287]): *Vata*, *Pitta*, and *Kapha*.[288] These *doshas* regulate different aspects of the human body:

> *Vata dosha* maintains the cellular transport, electrolyte balance, elimination of waste products and its effect is increased by dryness. *Pitta dosha* regulates body temperature, optic nerve coordination and hunger and thirst management. Heat conditions of the body aggravate Pitta. *Kapha dosha* is increased due to sweet and fatty food and it provides lubrication to the joints for proper functioning.[289]

Practitioners believe that disequilibrium of the *doshas* leads to poor health and disease.[290] In addition to the *doshas*, Ayurvedic practitioners consider the body's seven *dhatus*, or tissues—*Rasa* (tissue fluids), *Meda* (fat and connective tissue), *Rakta* (blood), *Asthi* (bones), *Majja* (marrow), *Mamsa* (muscle) and *Shukra* (semen)—and the three *malas*, or wastes—*Purisha* (feces), *Mutra* (urine) and *Sweda* (sweat).[291] These three constituents (*dosha*, *dhatu*, and *mala*) are said to be largely formed by nutrition and diet.[292] Finally, each patient falls into a different genetically-determined *prakriti* category, which helps the Ayurvedic practitioner determine a patient's susceptibility to particular diseases and conditions.[293]

Ayurvedic practitioners use food to impact the health of the mind and the body,[259] and recognize the different effects of various foods.[260] Foods are classified as *satvika* (promoting thought and intelligence), *rajsika* (good for physical labor), or *tamasika* (encouraging laziness).[261] Practitioners prescribe foods and diets based on their patients' individual *doshas*,[262] occupations,[263] and pre-existing medical conditions.[264] The goal of Ayurvedic dietary practices is to ensure a well-rounded diet that "contains different types of foods in such quantities and proportions that the need of the body is adequately met," wrote Das Banamali, a writer and researcher, in the *Journal of Homeopathy & Ayurvedic Medicine.*[265] It is important for practitioners to remember, however, that body needs vary from person-to-person; there is no one-size-fits-all approach to an Ayurvedic diet.[266,267]

In rural India, about 70 percent of the population still relies on Ayurvedic medicine,[268,269] and the NCCIH estimates that about 240,000 American adults also use Ayurvedic medicine.[270] There is, however, some concern that with the popularity of Ayurveda has come a deterioration in the standards of education for its practitioners.[271] In a study looking at knowledge and attitudes towards Ayurvedic medicine use among allopathic resident doctors, researchers found that:

> [a]llopathic residents had little knowledge about basic concepts of Ayurveda, that is, 'panchakarma' and 'tridosha.' Majority residents (99 percent) had no opportunity to learn the basics of Ayurveda, but 67 percent residents prescribed Ayurvedic medicines to patients. However, many residents (76 percent) mentioned that cross practice should not be allowed due to lack of knowledge.[272]

In 2014, the Government of India established the Ministry of Ayush to oversee the

development of traditional medical practices in India, including Ayurveda.[273] Within this Ministry is the National Institute of Ayurveda, committed to improving the quality of Ayurveda education and training.[274]

Research suggests that Ayurveda might have the potential to treat numerous chronic illnesses, including cancer, diabetes, and asthma.[275,276,277] However, the NCCIH's in-depth overview on Ayurvedic medicine, concluded the following with regards to its effectiveness: "A few studies suggest that Ayurvedic preparations may reduce pain and increase function in people with osteoarthritis and help manage symptoms in people with type 2 diabetes, but most of these trials are small or not well-designed. There is little scientific evidence on Ayurveda's value for other health issues."[278] Researchers have noted that in order to better serve the needs of patients, modern healthcare providers and Ayurvedic practitioners must find ways to integrate their treatment models and clinical drug trials.[279,280,281] Arvind Chopra, MD, a physician at the Arthritis Research and Care Foundation Center for Rheumatic Diseases, has been an advocate for integrating Ayurvedic treatment and Western medicine. According to Dr. Chopra:

We need to interpret logic of Ayurveda when, adopting modern science tools in drug development and validation and much research is required. Validation of Ayurvedic medicines using the latter approach may lead to an evidence based Ayurveda – Modern Medicine interface. Also, in pursuit of finding better treatment solutions, we ought to step beyond the realm of only drugs and attempt validation of comprehensive specific treatment package as per classical Ayurveda. Finally, validation of a combined (Ayurveda and modern medicine) therapeutic approach with superior efficacy and safety is likely to be a major leap in overcoming some of the current frustrations to treat difficult disorders like arthritis using only modern medicines.[282]

Food as Medicine in the New World (Western Hemisphere)

Various Native American tribes have also practiced food as medicine from ancient times until today.[306,307] Medicinal food and beverage plants were gathered and utilized by indigenous populations of eastern Canada to treat numerous physical ailments,[308] including gastrointestinal issues and musculoskeletal disorders.[309] Salal, a shrub native to the Pacific Northwest, is used by Native American people near the Puget Sound to treat heartburn, fever, sinus inflammation, and more.[310,311,312] Many of the medicinal plants used by Native American, Native Hawaiian, and Alaska Native tribes have also been documented by the National Library of Medicine, such as yucca, purple coneflower, and dandelion.[313]

A number of traditional Native diets are largely plant-based and have been found to help fight the chronic diet-related diseases that are prevalent in indigenous communities today, such as obesity and type 2 diabetes.[314] Native American diets consisted of corn, bean, squash, root crops, native berries, wild rice, fruits, nuts, seeds, and game—diets that are presently considered balanced and composed of whole foods.[315,316]

Of note, however, the Westernization of many Native American diets and lifestyles has been associated with the increase in diet-related diseases that are prevalent among these populations.[317,318] Perhaps the most striking example of this is among the Pima people of central Arizona, who have historically had one of the highest rates of obesity and type 2 diabetes in the world.[319,320,321,322] During the twentieth century, the Pima lifestyle changed from primarily hunting and gathering nutrient-dense foods to subsisting on high-fat processed foods provided by the United States government.[323] Furthermore, the Pima of Arizona used to work the land but today lead much more sedentary lives.[294] American settlers have pushed the native people off their lands, leaving them with little choice but to adopt a Westernized way of life, including higher-fat diets and less physical labor.[295] According to social science writer Malcolm Gladwell, writing for *The New Yorker* in 1998, the high rates of diet-related disease among the Pima have led to a sense of resignation, “that nothing can be done, that the way things are is the way things have to be.”[296]

Food as medicine principles were also practiced by the native peoples of the region now known as Latin America. For example, many of the ancient Mesoamerican people of Mexico used chile peppers from the genus *Capsicum* for a variety of purposes, including as medicine.[297] The Maya peoples in particular used the fruits, leaves, seeds, and even roots of the *Capiscum* to treat numerous ailments, including respiratory problems, gastrointestinal issues, earaches, and sores.[298] Researchers have also found *Capsicum* to have antimicrobial properties that can be used to fight off bacterial diseases such as tetanus.[299]

Medicinal plants, used extensively by many of these cultures, are still relied upon by many communities in Latin America and demonstrate potential to be used in modern medicinal treatments.[300,301] One such example is *yac”n*, a perennial flower with tuberous roots, traditionally grown in the Andes.[302] Nearly all of the plant is used in both the culinary traditions of the region and the medicinal practice – the plant is regarded by many as a functional food.[303] It is reported to prevent fatigue and cramps, relieve constipation, lower high blood pressure, and more.[304]

Animal products and foods have also had a long history of use in traditional medicine practices of Latin America; at least 584 animal species have been recorded as used in traditional medicine.[305] These species

range from reptiles to shellfish, insects to wild birds.[324] According to researchers Rômulo Alves and Humberto Alves writing in the *Journal of Ethnobiology and Ethnomedicine*:

> Hard parts, such as teeth, nails, shells, rattles from snakes, fish scales, bone and cartilage generally are sun-dried, grated and crushed to powder, being then administered as tea or taken during meals, while fat, body secretion and oil are either ingested or used as an ointment.[325]

The significance of medicinal plants in Latin America has led to a clear trend within the West of people seeking "exotic" remedies.[326] Traditional foods, such as açai and Peruvian root maca, are regularly marketed as "superfoods" that come from a primitive "nutritional utopia," write researchers Jessica Loyer and Christine Knight in *Food, Culture & Society*.[327] This "superfood" label is problematic for a variety of reasons (superfoods are discussed in further detail in Part II),[328] not the least of which due to the "commodity racism" they promote. Loyer and Knight write that these primitive superfoods "reinforc[e] neocolonial social relations by temporally distancing 'primitive' producers from modern Western consumers."[329]
An example of this can be found in quinoa, a grain native to the Andean region of South America.[330] The crop has been used by the native peoples of the Andes as both food and medicine for thousands of years, but since the late nineties it has been used to create various nutraceuticals and functional food products sold across the globe.[331] The marketing of quinoa often relies on its history and status as an "ancient grain," but companies selling quinoa often obfuscate the "social, economic, and ecological complexities surrounding the quinoa industries in Peru and Bolivia."[332]

Additional Cultures Practicing Food as Medicine

Similar to China and India, some parts of the Mediterranean, as well as many Islamic countries, still practice a form of ancient medicine known as Arab-Islamic herbal medicine or Traditional Arabic and Islamic Medicine, which is descended from Greco-Arab and Islamic medical practices.[333] Having inspired early European medical education,[334] these practices are used today to treat diseases such as cancer,[335] diabetes,[336] and liver disease.[337,338] While there is very little information reported on early Greco-Arab and Islamic medicine, there are a few sources which demonstrate the use of diet as the first line of defense against disease; only if food did not work would a physician turn to drugs.[339] According to Dr. Bashar Saad, professor of cell biology and immunology at the Arab American University in Jenin, Palestine, the modern use of Arab-Islamic medicine still relies on the use of medicinal plants and herbal remedies, many of which have been used in the development of modern pharmaceuticals.[340]

The Yoruba people of western Africa also have a history of traditional herbal medicine that has left an impact on their medicinal practices today.[341] The majority of rural Nigerians, for example, rely on traditional healers for their health care needs due to a lack of Western-trained healthcare professionals in the country.[342] Yorubic medicine uses a variety of medicinal plants and herbs native to western Africa, and herbalists are considered among the specialists in the traditional medicine discipline.[343,344] Many of these herbs have been used to develop modern medicinal treatments for disease.[345]

Spotlight: Garlic Throughout History and Cultures

Garlic has been used for its medicinal properties by numerous cultures throughout history.[346] Native to Central Asia, it is an integral component of Traditional Chinese Medicine,[347] Ayurveda[348] and other traditional forms of medicine around the globe. The ancient people of Sumer used garlic for its healing attributes,[349] while ancient Egyptians used it to stimulate laborers and slaves.[350] In ancient India, it was used to cure a variety of ailments, including hemorrhoids, cough, skin diseases and general weakness.[351] Richard S. Rivlin, MD, writing in the *Journal of Nutriton*'s "Recent Advances on the Nutritional Benefits Accompanying the Use of Garlic as a Supplement," said of garlic that "cultures that never came into contact with one another came to many of the same conclusions about the role of garlic in the treatment of disease."[352]

Among the earliest recorded uses of garlic as medicine is in the ancient Egyptian Codex Ebers, a medical papyrus from 1550 BCE.[353] The Egyptians were accomplished healers and were familiar with many medicinal plants, but garlic was the one used most often.[354] In the Codex Ebers, it is mentioned as a therapeutic remedy for headaches, bites, and tumors.[355] Artistic renderings of garlic have been found in ancient Egyptian tombs that date as far back as 3700 BCE, indicating the plant's importance in Egyptian culture.[356] From Egypt, garlic as a medicinal food made its way to ancient Greece, Rome, Israel and beyond.[357]

What properties does garlic have that makes it so popular as a remedy? Michael Netzel, PhD, a senior research fellow in the Centre for Nutrition and Food Sciences at the University of Queensland, wrote of it in a 2020 article from the peer-reviewed journal *Foods*:

> A broad range of biological functions and properties are attributed to garlic, including antioxidant capacity, anti-inflammatory activity, antimicrobial activity, modulation of the immune system, cardiovascular protection, anticancer activity, hepatoprotective activity, protection of the digestive system, anti-diabetic activity, anti-obesity activity as well as neuro- and renal-protection.[358]

However, Netzel notes that few of the reported features of garlic have been fully studied in humans, and more research is needed to understand its potential as a nutraceutical or functional food.[359]

Researchers have found that garlic has many disease-fighting components in humans.[360,361,362] Its organosulfur compounds, such as allicin (the compound that cause garlic's and onion's unique pungent aroma[363]), may provide an effective antiviral function.[364,365] And garlic extracts have also been found to have antioxidant properties,[366,367] although the level of effectiveness varies based on the region where the plant is grown.[368,369]

Studies have also shown that garlic has antimicrobial effects against bacteria, fungi, and parasites.[370,371,372,373] These antimicrobial properties led to the use of garlic as a mild antibiotic in the mid-nineteenth century, and as an antiseptic during World Wars I and II.[374] Finally, it has been used as a treatment for various bacterial diseases throughout history, including typhus, cholera, diphtheria, and tuberculosis.[375]

Consumption of garlic and other allium vegetables (e.g., onions, leeks, chives) have been linked to decreased risk of stomach and colon cancer.[376] The organosulfur compounds, in addition to potentially being antiviral,[377,378] are known to give it anti-tumor properties; some of these compounds can suppress tumor development and slow down the growth of tumors.[379]

Incorporating garlic into everyday foods is incredibly easy, as it can be added to nearly any savory dish to add aroma and flavor. For the best effects, crush or cut garlic before cooking, which releases the allicin.[380] Furthermore, overcooking garlic can destroy the enzyme that activates its disease-fighting compounds, so garlic should always be added toward the end of the cooking process.[381]

Spotlight: Mushrooms as Medicine, from Ancient Times to Present Day

Mushrooms have been used as medicine for millennia, and their use is seeing renewed interest in recent years.[382,383] However, "[u]sing these medicines require[s] both a working knowledge of toxic versus safe mushrooms and the ability to physiologically respond to the chemicals they produce," write researchers Paul Stamets, DSc and Heather Zwickey, PhD in the scientific journal *Integrative Medicine*.[384] Some mushrooms can heal, some can kill, and some can just be dinner; this diverse range of potential applications of mushrooms can make them particularly fascinating to study.[385]

Mushrooms are a good low-fat source of protein, dietary fiber, vitamin C, and B vitamins.[386] They also supply a good source of selenium,[387] which is needed for proper functioning of the thyroid gland.[388] In addition, research suggests that selenium may reduce the risk of lung, liver and prostate cancers.[389]

An example of a mushroom with numerous functional nutritional properties is the shiitake mushroom, or *Lentinus edodes*, which is a strong source of protein, fiber, B vitamins, and more.[390] Shiitakes also contain an important compound called lentinan, which has been shown to have antitumor and antimicrobial properties.[391]

Many of the bioactive compounds found in certain edible mushrooms have been associated with lowered risks for anxiety and depression among adults.[392,393] One mushroom in particular, *Hericium erinaceus* (known colloquially as lion's mane), has been associated with improved sleep quality and overall mood.[394,395]

The terms used in the marketing of mushrooms, however, are not always accurate.[396] "Wild mushrooms," for example, is an unregulated phrase, so products marketed as containing "wild mushrooms" do not always contain the wild mushrooms, such as porcinis and truffles that consumers may expect.[397] A 2021 study of food products using the label "wild mushrooms" found that cultivated mushrooms, such as shiitake and portobello, are frequently passed off as "wild."[398] Furthermore, a few food products were found to contain mushrooms that were potentially toxic.[399]

Mushrooms are also known for the psychedelic properties of certain species, a use that is receiving renewed interest.[400] The state of Oregon was the first to legalize the use of psilocybin-containing mushrooms (colloquially known as "magic mushrooms") for therapeutic purposes in 2020.[401] This move was the culmination of mounting media attention paid to psilocybin and "magic mushrooms," including from notable food writer Michael Pollan.[402,403] From a historical perspective, decriminalizing (and even legalizing) psilocybin is unsurprising to many, as it has been used by cultures around the world since ancient times to heal.[404]

Studies have shown that psychedelic therapies using psilocybin might have potential to treat psychiatric distress and addiction.[405] The Johns Hopkins Center for Psychedelic and Consciousness Research at Johns Hopkins University has done extensive research into the medicinal potential of psilocybin.[406,407] Researchers from this center have found psilocybin to be an effective tool in treating major depressive disorder,[408] alcohol use disorder,[409] and anxiety in cancer patients.[410] Furthermore, it has been found to facilitate smoking cessation.[411] It should be noted that in these studies, psilocybin was used as a part of a structured therapy regimen, including preparation and monitoring by a healthcare professional.[412]

An Anthropological and Historical Lens into Food as Medicine

In a *Journal of the History of Medicine and Allied Sciences* special issue, historians and researchers Juliana Adelman, PhD and Lisa Haushofer, MD, PhD explored food as medicine in relation to cultural norms and science.[413] The connection between food and medicine can often be categorized in one of two ways.[414] One approach is based on how food and medicine developed into distinct cultural practices, with fluid boundaries between the two, as is evident in Chinese, Ancient Greek, and Ayurvedic medicine.[415,416,417] The other focuses on recent scientific advances and how they have increased awareness of the medicinal potential of various foods.[418] Adelman and Haushofer write:

Nancy Chen's *Food, Medicine, and the Quest for Good Health* is a good example of the first way. Chen combined a historical and anthropological perspective on the development of eating and medicating as distinct cultural practices. While the book emphasizes the ways in which food and dietary prescriptions are shaped by culture, it also at times upholds a false dichotomy of science and culture. Science and medicine are seen as impacts on the cultural practices of eating, but the development of nutritional knowledge and scientifically informed dietary prescriptions are of course inseparable from particular or historically specific cultural forces. Through a historical survey of dietetic ideas in Ancient Greek, Chinese and Ayurvedic medicine, Chen argues that the boundary between science and medicine used to be much less blurred than it is at present. She adds that "[w]e may have something to learn from cultures that blur the boundaries between these categories."

An example of the second way is the work of anthropologist and ethnopharmacologist Nina Etkin. In her book Edible Medicines, she states that "until the recent and rapidly escalating interest in functional foods and supplements..., foods were regarded as virtually chemically inert, thus of no salience to disease processes." These two approaches to food as medicine are not mutually exclusive, of course; in fact, many accounts combine nostalgia for the past with enthusiasm for current nutritional science. The continued appearance of the famous misquotation falsely attributed to Hippocrates, "Let thy food be thy medicine, let thy medicine be thy food," in current works on medicinal foods… illustrates the desire to view recent nutritional science as a confirmation of past wisdom, and past dietetic practices as intuitive anticipations of modern knowledge.[419]

One suggested reason for the dichotomy between food and medicine is power dynamics, the intentional separation of medicine from food and agriculture in order to fit notions of the superiority of "civilized" as opposed to non-civilized intelligence.[420] Historians analyze food and medicine by exploring the balance of power between the two—the "professional" versus "layperson," "theoretical" versus "tacit" knowledge, and "experimental" versus "experiential" knowledge.[421]

Food as Medicine in Modern Society

The HIV/AIDS Pandemic and the Rise of Medically-Tailored Meal Programs

Additional interest in and advancement of food's impact on disease occurred during the HIV/AIDS pandemic of the 1980s and 1990s, which led to the emergence of numerous nonprofit organizations that used food to help people living with HIV/AIDS, including Project Open Hand in San Francisco (founded in 1985),[422] God's Love We Deliver in New York City (founded in 1986),[423] and Community Servings in Boston (founded in 1990).[424] These organizations were among the first to provide medically tailored meals to individuals managing disease and have yielded positive results with improved HIV health.[425]

In 1990, the United States Congress passed the Ryan White Comprehensive AIDS Resources Emergency (CARE) Act, creating the Ryan White HIV/AIDS Program.[426] This program funds grants to state and local governments as well as community-based organizations to provide services (including medically-tailored meals) to people managing HIV or AIDS.[427] This program has been described as a "model" of food and nutrition services for people living with chronic illness[428] that policymakers and healthcare professionals can look to when designing and implementing nutrition-focused health care intervention plans.[429]

Advancing Food as Medicine from a Policy and Practice Perspective

In the 1980s, physicians and researchers began paying more attention to the relationship between nutrition and physical health. Among these healthcare professionals is Dean Ornish, MD, who helped popularize the idea that you can treat and even reverse disease—particularly cardiovascular disease—by eating a diet rich in whole foods, among other lifestyle changes.[430,431] He founded the Preventive Medicine Research Institute in 1984 with the mission of researching how lifestyle medicine, including diet, can reverse, treat and prevent chronic diseases,[432] and since the 1990s has published numerous articles in medical journals.[433,434,435,436] The Preventive Medicine Research Institute has performed numerous trials and studies on the effect different food programs can have in managing diet-related diseases, including heart disease[437,438] and prostate cancer[439] among others. Currently, the Preventive Medicine Research Institute is conducting a trial to determine the effect of lifestyle changes (including diet) on the progression of Alzheimer's disease.[440]

In 1995, another notable physician, Caldwell Esselstyn, MD, published a benchmark, longitudinal nutritional study in the *Journal of Family Practice* demonstrating that a nutritious, low-fat diet could halt and even reverse coronary artery disease in severely ill patients.[441] Throughout Esselstyn's career, he published numerous studies on the impact of plant-based nutrition on diet-related chronic diseases such as coronary artery disease,[442,443,444] hypertension,[445] diabetes,[446] and retinopathy.[447] His work has influenced some notable politicians, including former President Bill Clinton[448,449] and New York City Mayor Eric Adams.[450]

There are many examples of other modern-day physician researchers, politicians, and advocates who have continued to build and expand on this work examining the

relationship between food and health, including David Katz, MD, PhD, Dariush Mozaffarian, MD, DrPH, Congressman Jim McGovern (D-MA), and Mark Hyman, MD.

Dr. Katz is a physician who has worked to advance the principles of food's impact on the prevention and treatment of disease. His experience includes work with various preventive and lifestyle medicine groups,[461] and he founded the Yale-Griffin Prevention Research Center,[462] the True Health Initiative,[463] and DietID.[464] He has more than 200 peer-reviewed publications about nutrition,[465] and in 2020 co-authored a book with notable food journalist Mark Bittman, *How to Eat: All Your Food and Diet Questions Answered*.[466]

Dr. Mozaffarian is a cardiologist, dean and Jean Mayer Professor at the Tufts Friedman School of Nutrition Science and Policy, and professor of medicine at Tufts Medical School. He is the Principal Investigator of Food-PRICE, a group of American researchers who investigate how to improve the diets of Americans and combat diet-related diseases such as heart disease, obesity, and diabetes.[467] He has published extensively about the connections between nutrition and health, including about the burden that diet-related disease places on the modern health care system.[468]

Congressman McGovern, a long-time hunger and agriculture advocate, launched the bipartisan Food as Medicine Working Group within the House Hunger Caucus in 2018. The group focuses on the impact hunger has on health and health care costs, as well as the importance of creating agricultural and nutrition policies guided by evidence-based health research that demonstrates access to affordable and nutritious foods like fresh produce leads to healthier communities.[469,470]

Dr. Hyman emerged as a leader in the functional medicine movement and is one of the more prominent social media influencers to post about food as medicine. He has published numerous bestselling books about nutrition[451] and hosted a PBS special in 2018 about nutrition and health.[452] However, his work is not without controversy; he sells dietary supplements to accompany a 10-day "detox" diet,[453] despite there being little evidence that detox diets work.[454] He also has received criticism for his cooperation with Robert F. Kennedy Jr. in writing a book about the debunked link between vaccines and autism.[455]

The increasing support of food as medicine among these notable figures has given the movement traction among even some of the oldest nutrition organizations, including the Academy of Nutrition and Dietetics (AND). The AND describes food as medicine as "a philosophy where food and nutrition aids individuals through interventions that support health and wellness."[456]

Distinct Dietary Patterns in the Blue Zones of Health

One of the most fascinating studies of the connection between food and its impact on health was performed in 2000 by Giovanni Pes, MD, PhD and Michel Poulain, PhD and published in 2004 in the journal *Experimental Gerontology*. The study identified Sardinia as the region of the world with the highest concentration of male centenarians.[457] In 2000, prior to beginning the study, National Geographic Fellow and author Dan Buettner launched a program with the goal of identifying the world's longest-lived people and their common attributes.[458] Pes, Poulain, and Buettner developed the Blue Zone certification in order to mark regions of the world where a higher than average number of people live longer than others.[459,460]

There are five Blue Zones identified around the world where people live significantly longer than people in other parts of the world.[471] Okinawa, Japan; Sardinia, Italy; Nicoya, Costa Rica; Ikaria, Greece; and Loma Linda, California are home to some of the longest living people in the world.[472] Longevity has traditionally been regarded as a marker of overall health, and Pes, Poulain, and Buettner's work illustrates how lifestyle choices and cultural practices factor into leading a long and healthy life.[473]

Pes, Poulain, and Buettner studied these zones to see what habits and lifestyle choices overlapped among such physically distant locations. Along with important choices such as exercise, quality time with friends and family, and having a sense of purpose, one of the greatest overlaps they found was diet.[474] They found that individuals living in Blue Zones ate primarily a plant-based diet heavy in beans and lentils and light in meats and dairy (just five 3-4 ounce servings of meat per month).[475]

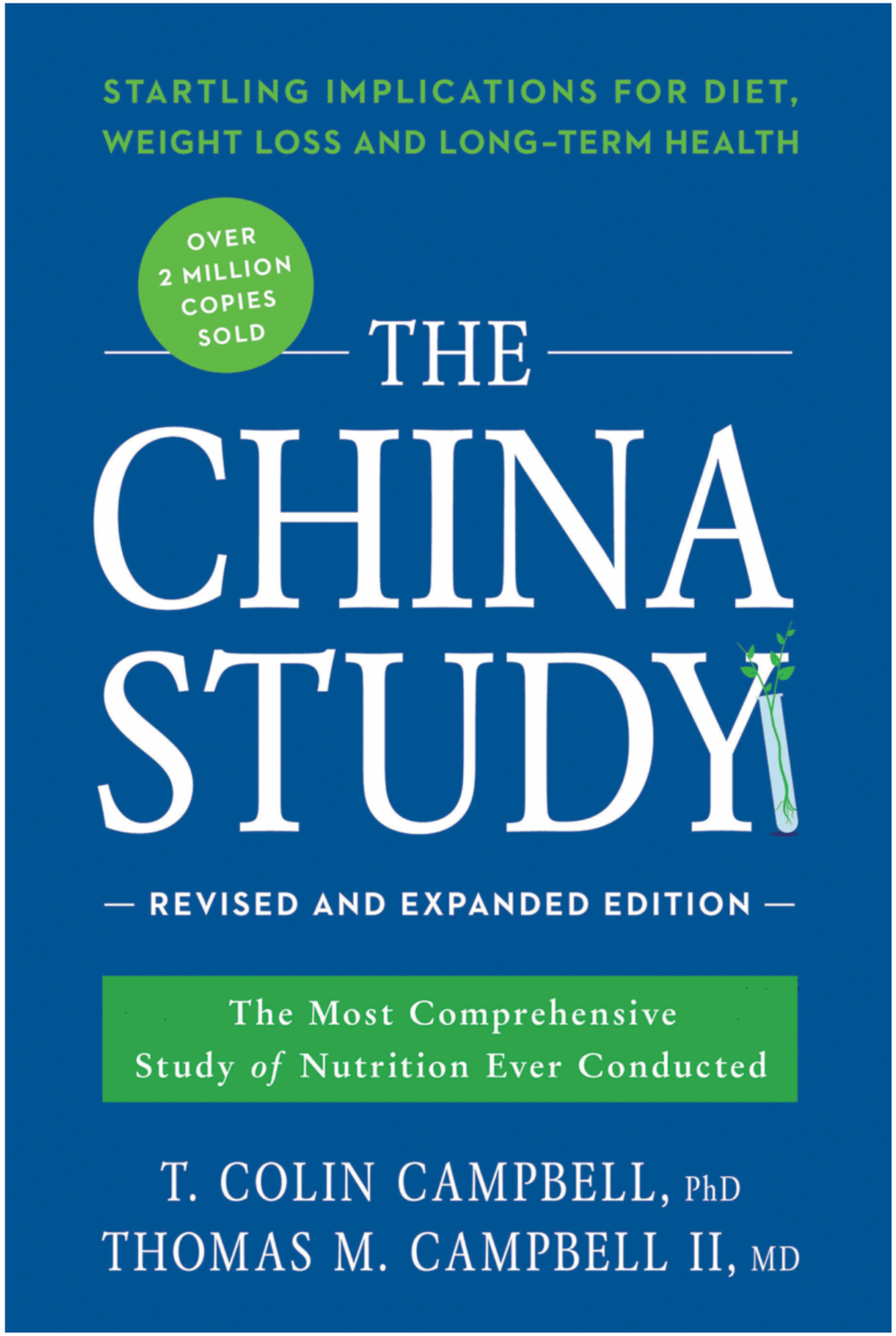
In total, nine common lifestyle habits, including dietary patterns, were identified among people living in the Blue Zones. According to their research, people that live the longest have a diet composed mostly of plants.[476] Leafy greens like spinach and kale, seasonal fruits and vegetables, and beans are the most common foods eaten by people in the Blue Zones.[477] And other foods consumed by these same people have also been identified as effective in treating specific diseases. For example, olive oil consumption, which is prominent among middle-aged people in Ikaria, has been shown to increase good cholesterol and lower bad cholesterol.[478] People with high levels of High-Density Lipoprotein (HDL) or good cholesterol have been shown to be at lower risk for heart disease and stroke.[479] Additionally, egg consumption, which was found to be low among all people living in the five Blue Zones, has been linked to higher rates of prostate cancer for men and aggravated kidney problems for women.[480] The research demonstrates the strong impact food has on overall health, and the link between physical health with quality of life.

The China Study: Connecting Diet & Chronic Disease

In their groundbreaking 2005 book, *The China Study: The Most Comprehensive Study of Nutrition Ever Conducted,* T. Colin Campbell, PhD, a long-time Cornell University researcher, and his son, Thomas M. Campbell II, MD, offer some of the most comprehensive research connecting diet and chronic disease in China.[481]

The Campbells found that genes on their own do not always determine diseases; but rather, nutrition plays a key role in which genes are actually expressed.[482] They also found that the same nutrition that prevents disease in early stages can be used to halt or reverse disease later on in life, and that nutrition that benefits one chronic disease tends to address a variety of disease states.[483] Their research even demonstrated that nutrition can help control the adverse effects of noxious chemicals.[484]

The Campbells also noted that nutrition is a matter of the combined activities of food substances and not the result of individual parts—in other words, vitamin supplements, either in pill form or added to food, are not an adequate replacement for nutritious whole foods.[485] For this reason nutrients will act differently from medicine, which tends to have quicker and more obvious "wins" when it comes to health.[486]



Spotlight: Interview with T. Colin Campbell by Charles Platkin, PhD, JD, MPH (2012)[487]

T.Colin Campbell is a retired professor of nutritional biochemistry at Cornell University who started his career doing research on how to make animals grow faster. His goal was to promote better health by advocating the consumption of more meat, milk and eggs. Then, more than 40 years ago, while he was a young researcher working on a project to help stamp out malnutrition in the Philippines, he came to a turning point that shifted the direction of his life's work. Now he's on a mission to share his compelling research on nutrition and diet with the world. He co-wrote a book called The China Study, (BenBella Books, 2005), based on his years of research showing the connection between nutrition and heart disease, diabetes and cancer. The study was the culmination of a 20-year partnership among Cornell University, Oxford University and the Chinese Academy of Preventive Medicine.

Here are a few answers to the Diet Detective's questions from the man whose research could be responsible for saving our lives by changing our diet.

Charles Platkin: Do we really need to be so worried about exactly what we're eating? Have we blown our "unhealthy" eating habits out of proportion?

Dr. T. Colin Campbell: Yes, and no. We obsess about details (which nutrients, which supplements, which specific ailments and diseases are candidates for therapy) but do not pay enough attention to the big picture (whole foods versus processed foods, plant versus animal source foods). Understanding the big picture has the most to offer – by far.

Charles Platkin: Could you tell us briefly about the genesis of The China Study?

Dr. T. Colin Campbell: In 1981, the Chinese government announced the results of a massive nationwide survey of cancer mortality for 2,400 counties, which showed that cancer was far more common in some areas than in others. Geographic localization was far more intense than in the U.S. because the vast majority of people in China resided in the same place all their lives and consumed locally produced food, at least in rural parts of the country. Americans move around and consume food from places far and wide, making it virtually impossible to do such a study.

Also, dietary lifestyle characteristics of people in rural China were substantially different from people in Western societies. These conditions presented an unparalleled and unique opportunity to compare diet, lifestyle and disease mortality rates with Western societies. It also allowed us to compare our results with our extensive and provocative laboratory animal findings obtained during the previous 15 years. I especially wanted to record as many different kinds of diet and lifestyle factors as possible in order to get information on "big picture" questions that seemed to be so contentious in the scientific and public communities.

Charles Platkin: In your book you state that, "Among the many associations that are relevant to diet and disease, so many pointed to the same finding: People who ate the most animal-based foods got the most chronic disease. Even relatively small intakes of animal-based food were associated with adverse effects. People who ate the most plant-based foods were the healthiest and tended to avoid chronic disease." There are some who disagree with this nutritional philosophy.

Dr. T. Colin Campbell: I don't like to respond to the assertion that people make decisions on the basis of "philosophy," which suggests that people are motivated by personalized agendas in making their decisions. Although I know this to be true for most people, this is not what motivated me. I simply did the research with my many students and colleagues and produced experimental findings that were peer-reviewed and published in the very best scientific journals. I then made my conclusions on the basis of actual empirical data. There was no philosophy involved. If I had a personal bias or philosophy in drawing my conclusions, it would have been exactly the opposite of these conclusions, given my many years on the farm milking cows.

My observation that "even relatively small intakes of animal-based food were associated with adverse effects" comes from the data showing that there is a high statistical significance between blood total cholesterol and aggregate chronic disease rates (i.e., "Western" diseases). This is especially interesting because dietary animal-based protein in this survey ranged only from 0 percent to 10 percent of total protein. Moreover, to observe such statistical significance within this very low range of animal-based protein and within such a low range of blood cholesterol is striking, especially when the blood cholesterol was so highly correlated with animal-source foods.

Charles Platkin: Are you suggesting that we all become vegetarians or vegans??

Dr. T. Colin Campbell: I have never suggested that we should all be vegetarians, because about 90 percent of vegetarians are still consuming food (i.e., dairy, eggs) with nutrient compositions that actually account for the adverse health effects of animal-based foods. Although consuming foods that trend in the direction of better health, vegetarians do not do what they could do. This suggests that vegans should do better, but they, too, compromise their potential benefits because they consume food that is highly processed. My recommendation is to consume a whole-food, plant-based diet without supplementing with added fat, salt, sugar and processed foods.

Whether people should eat this way is, of course, their choice. Besides, we know that a few people (5 percent) can deviate from this practice and still enjoy good health until advanced ages. But this may be analogous to the small number of smokers who live to their 90s and believe that it was their smoking that got them there. If we want to maximize our health, I believe that it would be prudent to go the whole way to an all-plant-based diet and allow ourselves the opportunity to discover some hidden and delicious tastes that are masked because of our addictions to high fat, salt and sugar. Who can calculate the 1 in 20 chance that they might escape the hazards of eating the wrong food? The real question is whether 100 percent plant-based diets are healthier than, say, 90 to 95 percent plant-based diets. This will undoubtedly depend on the differing responses of each individual, although I know of no scientifically valid

data showing that people consuming a plant-based diet suffer more and die earlier. Indeed, the findings are clearly to the contrary.

Charles Platkin: You also claim that your research showed that the protein casein, which makes up 87 percent of cow's milk protein, promoted all stages of the cancer process. Are you saying that animal protein promotes cancer?

Dr. T. Colin Campbell: In our experimental animal studies, casein as an animal protein promotes cancer, in spades. Of all the experimental research my laboratory did, this may be the most convincing. In fact, our findings, done in so many ways, show that casein is the most relevant chemical carcinogen ever discovered. I have presented this information in seminars to virtually all the relevant agencies and research groups who do these kinds of studies, and have published the results in the very best peer-reviewed scientific journals. These findings also are consistent with similar promoting effects of casein on the development of experimental atherogenesis (the lesion leading to heart disease) and rising blood cholesterol levels, among other toxic events.

Charles Platkin: What is the healthiest diet to prevent disease and live our best life?

Dr. T. Colin Campbell: The closer we get to a whole foods plant-based diet with minimal or no use of added oil, sugar, salt or processed foods, the healthier we will be. On interpreting the scientific evidence, I mostly rely on statistical odds and biological plausibility, which overwhelmingly point in the direction of a plant-based diet. But I become substantially convinced when I see the clinical evidence achieved by my physician colleagues.

Charles Platkin: What about all the white rice the Chinese eat? We've been taught that rice should always be brown – that is, 100 percent whole grain?

Dr. T. Colin Campbell: Yes, white rice is not the most desirable. It likely would be better for the Chinese to eat whole-grain rice.

Charles Platkin: You say that the real science about "food and nutrition has been buried beneath a clutter of irrelevant or even harmful information." Can you please explain more specifically what you mean, and why this has occurred? What's wrong with nutrition research today? Is it tainted by corporate research dollars and National Institutes of Health mandates? Can we trust what we read in the media?

Dr. T. Colin Campbell: This is a very big, important and complex story. We do the wrong thing in nutrition research, not just because we misunderstand nutrition but even more because we misunderstand what the words "health" and "medicine" mean.

If I were to put my finger on one explanation of the extraordinary confusion in nutrition research, I would say that it is the way that nutrition is defined. Nutrition should not, for example, be defined as the biological effects of single, isolated nutrients but as the collective, highly integrated effects of all active substances in plant-source foods. The practice of medicine is the antithesis of nutrition. It relies on the biological effects of individual chemicals (e.g., drugs or nutrient supplements) acting independently and, to make matters much worse, on chemicals not in their natural form but in a synthetic form.

Aside from this scientific argument, there also are highly socio-historical, economic and political factors wherein special interests from the food and drug industries exert their enormous power to influence science agencies, regulatory authorities, politicians and the media in order to sway public opinion in favor of their products and profits. I spent about 20 successive years almost continuously involved in some aspect of food and health policy development and witnessed first hand a devastating effect of corporate interests on public nutrition information. Our system is about creating wealth for the few at the expense of health for the many – and using public taxpayer dollars to do this dirty work! The media merely carry the message of the food and health cartels and mostly know not what they are doing. Trust what you read in the media at your own peril.

Charles Platkin: Do we really need to be buying organic foods? If so, why? What's the compelling argument for or against?

Dr. T. Colin Campbell: I prefer using organic food but must confess that convincing and direct scientific evidence for its health benefits is lacking, although there is certainly some reasonable indirect evidence to support health benefits from these foods.

Charles Platkin: If we don't eat well, should we be taking a multivitamin and/or supplements?

Dr. T. Colin Campbell: No. There now is ample evidence that (except perhaps for B12 and maybe vitamin D) taking vitamin supplements is, at a minimum, a waste of money and at worst, may actually cause harm.

Charles Platkin: What's your favorite breakfast?

Dr. T. Colin Campbell: A bowl of either cold or hot cereal (whole grain) with fresh or frozen fruit, various dried fruits (raisins, figs) and a sprinkle of nuts. A breakfast of whole-grain pancakes with a large dollop of fruit puree, maybe some maple syrup, with no added oil to the pancake mix, also is delicious. My wife does it exactly right.

Charles Platkin: What's your favorite "junk food"?

Dr. T. Colin Campbell: When my wife is not looking, a piece of strongly flavored cheese. But it has to be someplace else because it is not to be found in our house.

Food as Medicine in Popular Culture

Documentaries Bring Food as Medicine into Public Discourse

One of the earliest documentaries chronicling the relationship between food and health was the 2004 *Super Size Me*. Filmmaker Morgan Spurlock ate exclusively McDonald's fast food for thirty straight days, and the documentary follows the changes to his physical and mental health that occur as a result of this drastic shift.[488] Shortly after the film was released, McDonald's discontinued the "supersize" option;[489] however, the company alleged that the decision to stop selling "supersize" portions was entirely unrelated to the film.[490]

The food as medicine movement gained further attention with the release of the 2011 documentary, *Forks Over Knives*.[491] The film was the culmination of more than ten years of research by executive producer Brian Wendel into the health effects of a plant-based diet.[492] In the film, he interviews major figures in the plant-based food as medicine movement, including T. Colin Campbell and Caldwell Esselstyn.[493] After the documentary's release, the Forks Over Knives brand has expanded to include multiple cookbooks, a cooking course, and a meal planning service.[494] It has been described by many media outlets as a film that, even if it does not convince the audience to turn to completely plant-based diets, will force viewers to think more critically about the food they eat.[495,496]

In 2017, director Robert Tate released *The Magic Pill*, which diverted from the plant-based focus of *Forks Over Knives*. In *The Magic Pill*, the health benefits to high-fat, meat-heavy diets (such as the ketogenic diet) are explored.[497] That same year, documentarian Kip Andersen released *What the Health*, which explores the role that big business plays in public health and the epidemic of diet-related disease.[498] Joaquin Phoenix, acclaimed actor and vegan activist, acted as an executive producer on the film.[499] The film was criticized by reviewers for cherry-picking science studies and distorting scientific data.[500,501,502,503]

The cultural impact of this popularization can still be seen today. Numerous professional athletes have publicly extolled the benefits of plant-based diets in particular; former NFL lineman David Carter switched to a vegan diet in 2014 after watching *Forks Over Knives*.[504] The popularity of veganism among athletes is the primary focus of Netflix's 2019 documentary, titled *The Game Changers*, which strongly promotes a plant-based diet.[505] It featured many of the major figures in the Food as Medicine movement, including Dean Ornish, Caldwell Esselstyn, and David Katz, alongside very well-known celebrities such as Arnold Schwarzenegger.[506] This documentary highlighted athletes (especially men) who follow vegan diets, using the term "plant-based" in an attempt to broaden the appeal.[507] However, the film was criticized for citing very little reputable research and relying heavily on anecdotal evidence instead.[508]

Spotlight: Significant Food As Medicine Documentaries

Super Size Me (2004), dir. Morgan Spurlock

Food Matters (2008), dir. James Colquhoun and Carlo Ledesma

Killer at Large (2008), dir Steven Greenstreet

Fat, Sick and Nearly Dead (2010), dir. Joe Cross and Kurt Engfehr

Forks Over Knives (2011), dir. Lee Fulkerson

Vegucated (2011), dir. Marisa Miller Wolfson

Hungry for Change (2012), dir. James Colquhoun and Laurentine ten Bosch

A Place at the Table (2012), dir. Kristi Jacobson and Lori Silverbush

Bite Size (2014), dir. Corbin Billings

Fed Up (2014), dir. Stephanie Soechtig

That Sugar Film (2014), dir. Damon Gameau

PlantPure Nation (2015), dir. Nelson Campbell

Food as Medicine (2016), dir. Lenore Eklund

Food Choices (2016), dir. Michal Siewierski

The Magic Pill (2017), dir. Robert Tate

What the Health (2017), dir. Kip Andersen and Keegan Kuhn

H.O.P.E. What You Eat Matters (2018), dir. Nina Messinger

Meat Me Halfway (2021), dir. Brian Kateman and Journey Wade-Hak

They're Trying to Kill Us (2021), dir. Keegan Kuhn and John Lewis

The Impact of Food as Medicine Online

According to the National Telecommunications and Information Administration (NTIA) in the United States Department of Commerce, more than half of American households used the internet for health-related activities in 2019.[509] In its survey, NTIA reported that

> The proportion of households that accessed health or health insurance records online grew from 30 percent in 2017 to 34 percent in 2019. Households communicating with a doctor or other health professional online grew by two percentage points, and households that researched health information online grew by one percentage point between 2017 and 2019.[510]

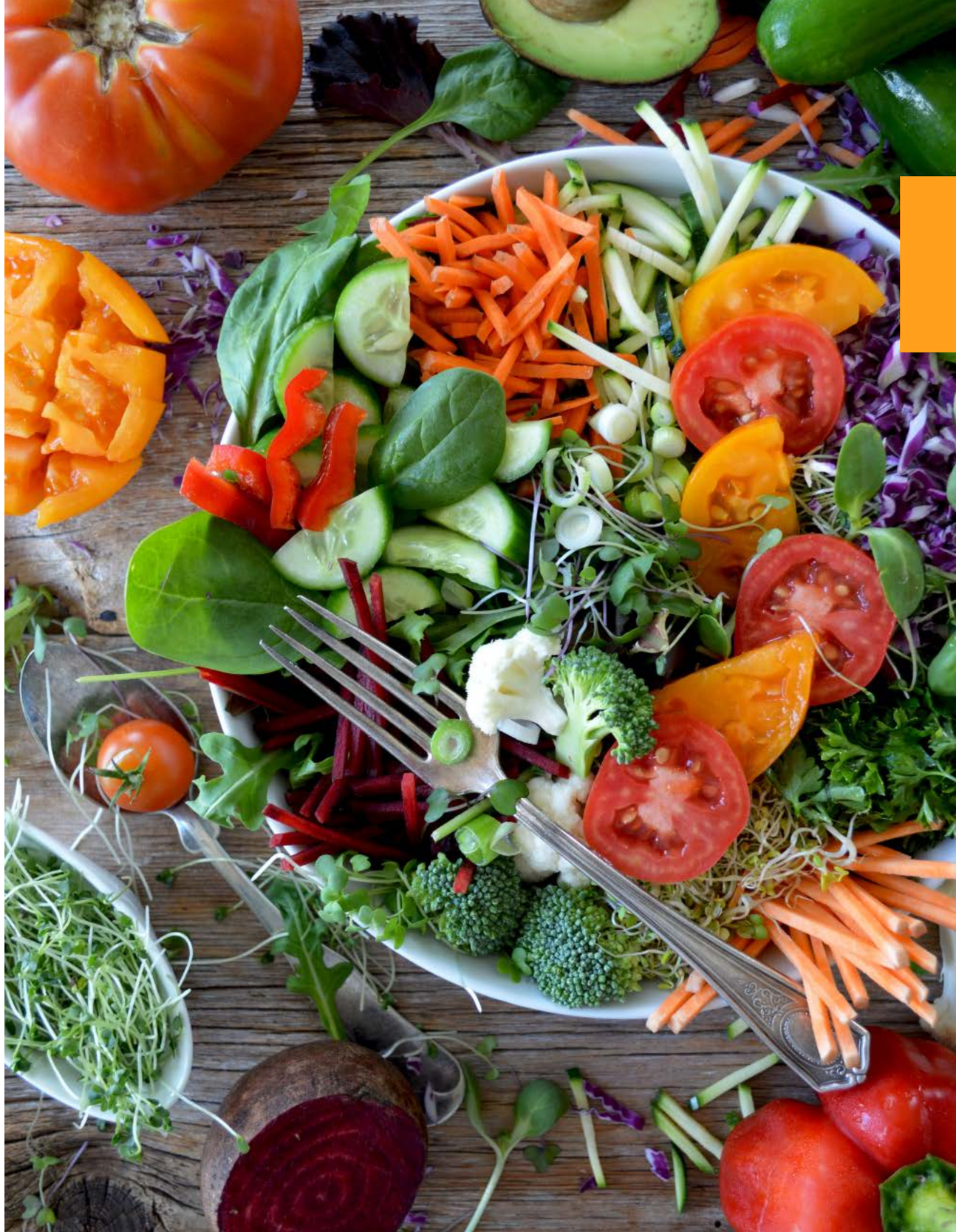
As individuals seek to make sense of their health, a majority of Americans, at least 60 percent according to some estimations, turn to the internet as a source of medical information.[511,512] Additionally, searching for information about nutrition and diet online has increased substantially.[513] According to research published in *PLOS One*:

> [W]omen, young users, users with a university education and nonsmokers are most likely to use the internet and mobile applications for health-related purposes. On search engines, internet users most frequently search for pharmacies, symptoms of medical conditions and pain. Moreover, users seem most interested in information on how to live a healthy life, alternative medicine, mental health and women's health.[514]

However, with this increased desire for information, there is also an increased abundance of misinformation.[515] There is a lack of credibility to much of the health, and nutrition-specific information published online.[516] Many health-related blogs and websites corroborate information using experts with advanced health degrees,[517] which causes readers of these sites to be more likely to trust the information they find.[518,519] However, online health information may still be misleading and have inaccurate claims.[520] In fact, baseless trends and sensationalist news reports create opportunities for misinformation to proliferate, providing information that may sometimes be dangerous.[521,522] While some individuals may be skeptical of government websites (such as the FDA,[523] USDA,[524] and the U.S. National Library of Medicine's MedlinePlus[525,526,527]) it can be valuable in offering a baseline level of information or a starting point, that along with original research from scholarly search engines such as PubMed or Google Scholar, can provide a starting point for individual health information research.[528]

The accuracy of information published on websites and blogs is not governed by any regulatory agency; therefore, websites with evidence-based content coexist with those containing inaccurate, incomplete, or misleading information.[529] Nutrition misinformation can be disseminated with false intent to sell products[530] or promote a personal philosophy or that of a special-interest group.[531] Research has routinely shown that consumers who do not have a background in nutrition science often feel confused by information available to them, including information found in studies, news articles, and on social media.[532,533,534,535]

Many of the people who use the internet to search for health information have a lack of trust in the traditional medical establishment,[536,537,538,539] which has been exacerbated by the COVID-19 pandemic.[540] Skeptics of the modern health care system have expressed frustration that their desire to learn about alternative treatment options, including dietary intervention, were largely ignored or even rebuffed by their traditional healthcare provider (which includes physicians).[541] This lack of support from the medical system pushed many to seek information on the internet.[542]



Spotlight: Deciphering Health Information Online

By Charles Platkin, PhD, JD, MPH

You wake up one morning and see that you have an unidentified rash on your hand. What's one of the first things you do? Probably, if you're like most Americans, you go to your smartphone or computer and start searching for what disease you have. The statistics are staggering – nearly 75 percent of Americans are looking online for health information. As Mark Twain said: "Be careful about reading health books." The reality is you can't always trust what you read. Here are a few tips from a variety of sources (e.g. the Medical Library Association, NIH's US National Library of Medicine, Medline Plus and a few other reliable sources) to help make sure your future health searches yield more accurate results.

Who Owns or Is Responsible for the Website and Its Content?
Ask yourself the following questions:

- Who or what entity created the website or is responsible for the information?
- Does the site have an email address, or is the only way to contact the organization through a web or contact form? Make sure their contact information is accurate and detailed.
- Who owns the site? Is there an "About" or "About Us" section? Is it a not-for-profit, and, if so, who is funding? There are some nonprofits that are funded by specific interest groups or corporations. Is it a corporation? If so, what kind—hospital, university, etc.?
- Does it explain the mission and purpose of the website? Is there an address? If you look it up on a search engine "street image," what does it show?
- Why was the website created? What is its purpose and what do they gain? Is it educational? Corporate? Trying to sell a product or service?
- Does the "About Us" section list names of individuals associated with the site? If there is an individual identified, what are their credentials (PhD, Masters – and from what university? Is it accredited?)?
- Is it clear who they are and what they do for the site? You might even do a search for that person's name – see what comes up.
- Are the individuals involved with the site backed by a known nonprofit organization (e.g., government, university, or research center)?
- What is the domain name? This is not always the best indicator; however, typically a ".edu" or a ".gov" is a good start, while ".org" is not necessarily a guarantee that it's a legitimate organization.
- Is there an advisory board? If so, who is on the advisory board?

Facts? Opinion? Bias?

- Check to see if the information on the site is based on the latest scientific research – the "state of the science." You can always look on pubmed.gov or search in Google Scholar using key words and seeing what research articles show up. You can filter results by year too.
- Information should be presented in a clear manner. It should be based on fact and verifiable from primary sources such as professional / scientific literature, peer-reviewed journal articles, and other scholarly researched, university backed sources.
- Is the information showing only one point of view? Check multiple websites, especially university and government research organizations (such as CDC.gov and NIH).
- Information that is opinion should be clearly stated on the website and the source or sources of the information should be identified.
- Are there advertisers or sponsors on the site? Who are they? What type of ads? Keep in mind, most government websites, hospitals, universities and other non-profits don't take ads or have sponsors.
- Is advertising clearly marked as a sponsored? Many sites create advertorials – advertisements disguised as editorial content or information from reliable health sources.
- Look carefully to see if the site is a front for a corporation, pharmaceutical company, or another biased organization.
- Check the style and display of the site information including the graphics, colors, fonts, and size of text. Watch out for all capital letters, exclamation points, and anything out of the ordinary.
- Has the material been reviewed or vetted by an expert, such as an MD or PhD in the field?

Is the Information Accurate and Timely?

- Are the sources cited reliable?
- Is there a date on the page?
- When was the last page updated? The site should be updated frequently. Health information changes constantly as new information about diseases and treatments is discovered through research and patient care. What was published a year ago may be outdated now.
- Do the links work?

- Are there grammatical and spelling errors?
- Are there citations, footnotes/endnotes, bibliographies, or references so that you can verify the information? Are these reliable? Do they link to the sources?
- Does the site have a seal of approval from an unbiased accrediting body such as "Health On the Net Foundation (HON)?" HON is a non-profit, non-governmental organization, accredited to the Economic and Social Council of the United Nations. For 15 years, HON has focused on the essential question of the provision of health information to citizens, information that respects ethical standards. (See: https://www.healthonnet.org/)
- If the website is quoting research studies, follow these tips from the Harvard School of Public Health on Deciphering Media Stories:
    - Is the story simply reporting the results of a single study? Only very rarely would a single study be influential enough for people to change their behaviors based on the results. So it is important to see how that study fits in with other studies on the topic. Some articles provide this background; other times, you may need to do more digging on your own.
    - How large is the study? Large studies often provide more reliable results than small studies.
    - Was the study done in animals or humans? Mice, rats, and monkeys are not people. To best understand how food (or some other factor) affects human health, it must almost always be studied in humans.
    - Did the study look at real disease endpoints, like heart disease or osteoporosis?

Your Privacy Matters

- Your health information should be confidential, and if you research a disease or condition that should also be private.
- There should be a link saying "Privacy" or "Privacy Policy." Read the privacy policy to see if your privacy is really being protected.
- If there is a registration form, personal information required, or questions you have to answer before you can view content, you should probably skip it.

Additional Help

- The Medical Library Association's Consumer and Patient Health Information Section regularly reviews websites for inclusion on their "Top Health Websites" page: http://www.mlanet.org/p/cm/ld/fid=397

Others who use online sources as their primary tools for making sense of their health are driven by the desire to receive a quick and more However, consulting online sources (often referred to as “Dr. Google”), can lead people toward treatment approaches that lack scientific evidence.[543,544] Additionally, excessive searching for online health information has been linked to increased anxiety and distress, a phenomenon known as “cyberchondria.”[545] There are also issues that health information seekers are often frustrated when searching for the medical and health information they want. Approximately 60 percent of health seekers found the process of finding health information frustrating.[546] Furthermore:

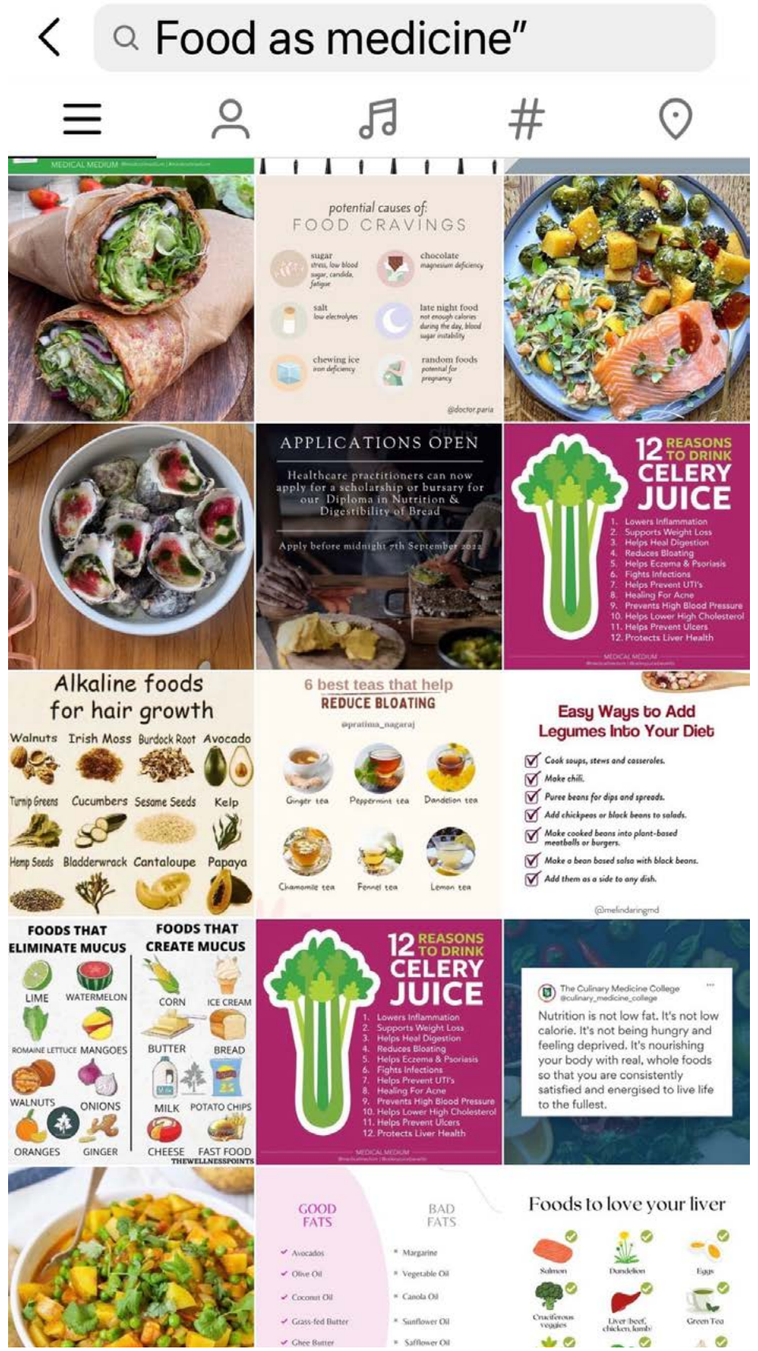
> [i]n studies published during the last decade, persons who reported greater difficulty in seeking health information online were more likely to be from socially disadvantaged groups, including racial/ethnic minority groups, older adults, those with lower incomes, and persons living in rural areas; more likely to report negative perceptions about health care; and more likely to be misinformed about cancer prevention than those from relatively advantaged groups.[547]

As internet literacy improves across the board, more and more people will turn to it to answer their health questions without seeking the advice of their healthcare professionals.[548] Patients want to feel more in control of their health decision making,[549] altering their relationship with their physicians.[550] Researchers Sharon Swee-Lin Tan and Nadee Goonawardene wrote in the *Journal of Medical Internet Research* in 2017 that healthcare professionals need to consider ways to adapt their services in the internet world in order to improve the patient-physician relationship.[551] Key to rebuilding trust among patients in their healthcare professionals is transparency; people want to know what doctors and other healthcare providers are doing and why they are doing it.[552,553]

Food as Medicine on Social Media

In the age of social media, platforms including Facebook, Twitter, Instagram, and TikTok are also increasingly popular sources of health information.[554,555,556,557] Many users turn to these sites looking for food-based ways to prevent, manage, and treat disease.[558] The extensive number of pages devoted to using food as medicine attest to this interest among users.[559,560,561] Unfortunately, the accessibility of *evidence-based* information about food as medicine has not kept pace with its booming popularity.[562,563,564,565,566] Information circulated on social media and the internet can often be unsound and inaccurate, especially information about food and diet.[567,568,569] Misinformation is extremely prevalent in online discourse,[570,571] and even young, tech-savvy users fall for inaccurate claims on the internet and through social media.[572,573,574,575] Many Americans struggle to understand medical information, leaving them susceptible to misinformation spread through social media.[576,577] Research by the Institute of Medicine indicates that approximately half the adults in the United States lack the ability to make informed decisions regarding their health, a phenomenon that has been called a “health literacy epidemic.”[578,579] “Health literacy” refers to an individual’s ability to take responsibility for his or her health and understand the factors that impact it.[580,581]

Often health claims come from social media influencers who profess food-based solutions to common health conditions.[582,583] These accounts attract large, eager fan bases with some influencers and have been shown to have a significant impact on the food and health practices of social media users.[584,585,586] A 2017 survey appearing in *Proceedings of the Nutrition Society* conducted across all age groups found that a majority of users, 59 percent, followed influencers on social media,



Spotlight: What are Dietary Supplements?

The U.S. Food and Drug Administration (FDA) maintains that dietary supplements include vitamins, minerals, amino acids, and herbs or botanicals, as well as other substances that can be used to supplement the diet but are not intended to treat, diagnose, cure, or alleviate the effects of diseases.[587] According to the 2012 National Health Interview Survey, 89 percent of American adults who took dietary supplements other than vitamins and minerals were interested in general wellness or disease prevention and improved immune function, memory, or energy.[588] As the FDA treats dietary supplements differently from conventional pharmaceuticals (does not have the authority to review dietary supplement products for safety and effectiveness before they are marketed), manufacturers can make certain kinds of health claims without submitting their product for review by the agency.[589] Companies can promote their products by using statements that describe the documented impact of their nutrient ingredients on improving or maintaining the "structure/function" of the human body.[590] "Structure/function" claims are differentiated from disease claims because they reference the health of an organ or mechanism of the body rather than purporting to impact the signs and symptoms of disease.[591] Some dietary supplements have not been proven to work, and studies of some supplements have not supported claims made about them.[592] Although dietary supplements that feature structure/function statements are required to include disclaimers stating that their products have not been evaluated by the FDA, their claims still entice consumers to buy these products in the hope, often false, of mitigating disease.[593] [See: National Center for Complementary and Integrative Health's Herbs at a Glance and Health Topics A-Z]

The NCCIH supports research into dietary supplements and how they affect the body, and provides information to consumers interested in taking supplements for their health.[594] Some dietary supplements are well-researched and known to be generally beneficial for certain conditions, such as melatonin;[595] others have little evidence supporting their use, such as echinacea in the treatment of the common cold.[596]

and 16 percent of users considered the opinions of these influencers to have a notable impact on their food choices. [597]

Claims spread via social media platforms such as TikTok are often not only false but potentially dangerous. For example, in the spring of 2021, influencers on TikTok encouraged the use of liquid chlorophyll as a cure for acne.[598] However, some dermatologists caution against taking liquid chlorophyll for acne without the guidance of a medical professional because a photosensitizing agent such as chlorophyll can be very damaging to skin as it accumulates and can cause rashes, burning, and stinging.[599,600] The key issue is that this has not been tested or scientifically tested and proven to be impactful or safe. There is a high demand for misinformation, and validation of alternative scientific and medical information. This information has a high believability and low skepticism by the recipients.

Researchers have used social contagion models, which study how people influence one another in belief, affect, and behavior, to demonstrate the important role these popular figures have played in the rise of veganism over the past decade.[601] For many platform users, influencers are trusted sources of food information as well as aspirational figures.[602] Followers are eager to emulate their attractive physiques and glamorous lifestyles by following their health advice;[603,604] which, in recent years, this advice has attracted many increasingly pushed Americans towards certain diets.[605]

Some health claims on social media are funded by companies selling dietary supplements, weight loss products, and other food-based health solutions.[606,607,608] According to a 2017 estimate, at least 75 percent of advertisers in the United States employ social media influencers as part of their marketing strategy.[609,610] Many of their followers are teenagers and young adults—41 percent of TikTok users are between the ages of 16 and 24[611]—who are highly responsive to messaging that they perceive to come from their peers.[612] As a result, an estimated 60 percent of food and beverage promotions are now endorsed by social media influencers.[613]

Rising Popularity of Plant-Based and Plant- Forward Diets

Plant-based diets are eating patterns that emphasize the consumption of foods derived from plants, including fruits, vegetables, nuts, seeds, oils, whole grains, legumes, and beans.[614,615] Roughly a century ago, most people ate predominantly plant-based foodstuffs.[616] Industrialization, which increased standards of living while decreasing the costs of meat, fish, and fowl, contributed to animal products to become staples of the American diet.[617,618] Federal subsidies for dairy and livestock, in part via subsidies on feed grains, contribute to artificially low meat prices in the United States, making animal-based foods much more affordable and accessible.[619,620] The government in the United States spends more than $38 billion annually on crop insurance and commodity programs for farms (most of which go to the production of corn, soybeans, and other field crops that can be used as feed for livestock);[621,622] however, less than one percent of that amount is allocated to fruit and vegetable production due to their status as "specialty crops."[623,624]

The shift towards plant-based eating reflects a variety of changes to how Americans understand and approach their food. Today, some of the most popular plant-based diets, including vegetarianism and veganism, exclude many or all animal products.[625] Other plant-based diets emphasize flexitarianism and reducetarianism rather than eliminating all fish, meat, and dairy.[626,627]

Spotlight: NYC Mayor Eric Adams' Reversal of Type 2 Diabetes Through Diet

In 2016, then-Brooklyn Borough President Eric Adams, author of *Healthy at Last: A Plant-Based Approach to Preventing and Reversing Diabetes and Other Chronic Illnesses* (Hay House Inc., 2020) was diagnosed with type 2 diabetes.[628] He lost the vision in his left eye and suffered nerve damage in his hands and feet.[629]

After researching the potential treatment and management options for diabetes, he found Dr. Caldwell Esselstyn's research, and decided to follow a whole-food, plant-based diet.[630] "I remained skeptical that I could ever enjoy eating this way, but I was determined to take charge of my health," Adams wrote in his 2020 book.[631] Within months, Adams reversed his type 2 diabetes and now works to educate the community about how to make informed decisions about food.[632]

A lifelong New Yorker, Adams was a police officer for 22 years and retired at the rank of captain.[633] He began his first of two terms as the Brooklyn Borough President in 2013—the first person of color to be elected into the position.[634] In 2022, Eric Adams became the 110th mayor of New York City.[635]

Some pursue these diets out of ethical and animal rights concerns, such as the treatment of livestock and the morality of eating other living things.[665,666,667] Some also cite the ecological and environmental impact of raising animals for food production, including the creation of methane and a drain on water and land resources, as reasons for turning to plant-based foodstuffs as climate change intensifies.[668,669,670]

Although there are several factors contributing to the increase in plant-based eating, the perceived health benefits of these diets play a substantial role in their popularity.[671,672,673,674,675,676,677] The choice to be a vegan based on dietary and health preferences rather than ethical beliefs may have a broader appeal because it is framed as a personal choice to improve one's physical wellbeing.[678,679,680,681] Plant-based diets have become trendy lifestyle choices advocated for by celebrities and social media influencers.[682,683,684]

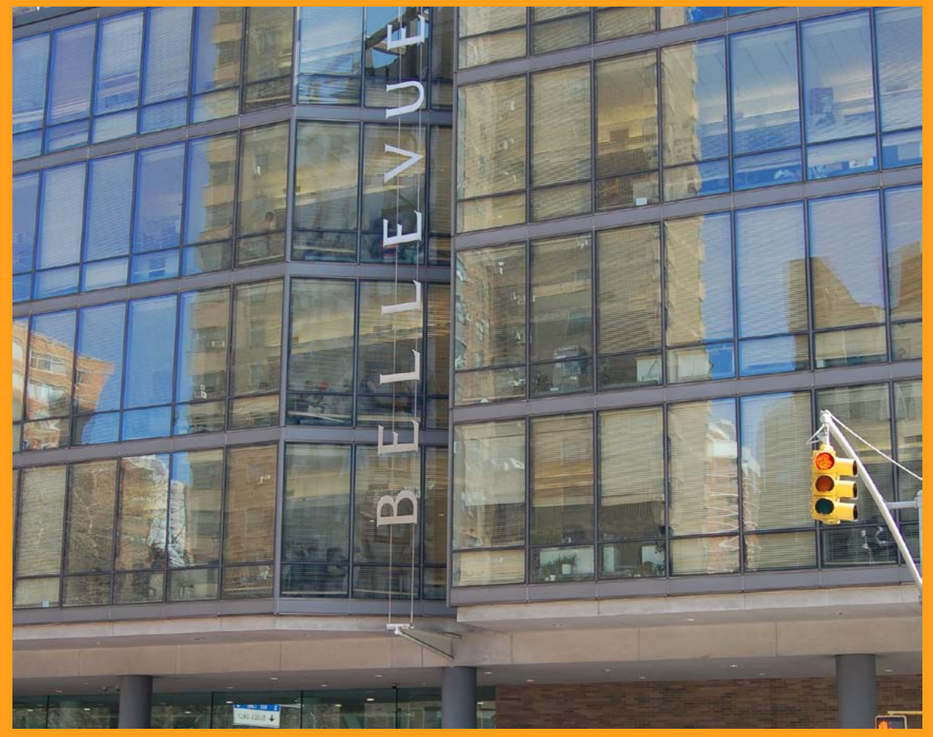
Plant-based diets have well-established health benefits and are aligned with nutrition recommendations from major medical societies—including the American College of Cardiology / American Heart Association, the American Association of Clinical Endocrinology, the American Cancer Society, and the American Institute for Cancer Research—whereas processed and red meats as well as whole-milk dairy products contain saturated fats that have been linked to the development of cardiovascular disease and obesity.[685,686] Whole grains, fruits, vegetables, legumes, nuts, and seeds—foods at the core of plant-based diets—are linked to significantly lower risk of cardiovascular disease, cancer, type 2 diabetes, and obesity.[687,688,689] In addition, dietary substitution of plant protein instead of animal protein has been linked to decreased cardiovascular disease mortality risk.[690] By reducing meat and dairy consumption in favor of vegetables, fruits, and whole grains—foods that serve as the cornerstones of both the USDA's and the WHO's dietary guidelines—an individual can improve their nutritional intake and reduce their risk for chronic disease.[636,637,638] Large observational research studies have found that plant-based eaters have lower rates of heart disease,[639,640,641,642] type 2 diabetes,[643,644] certain types of cancer,[645] obesity,[646] and hypertension[647,648] relative to those who do not maintain plant-based diets. In addition, randomized clinical trials have shown that plant-based diets can be effective for the treatment of type 2 diabetes,[649,650] hypertension,[651] hyperlipidemia,[652] and obesity.[653] Plant-based diets may provide other health benefits as well, including decreased inflammation,[654,655] better kidney health,[656,657] and improved gut microbiota profiles;[658] in addition, a 2021 randomized controlled trial found that in menopausal women, a low-fat, vegan diet supplemented with soybeans led to fewer, less severe hot flashes and improved quality of life.[659]

In recent years, a number of studies have highlighted the distinction between healthful plant-based diets, which are rich in minimally processed plant foods, and unhealthful plant-based diets, which emphasize sugar-sweetened beverages, refined grains, fried foods, and other ultra-processed foods.[660] Unhealthful plant-based diets have been linked to higher rates of heart disease[661] and type 2 diabetes,[662] similar to diets high in animal foods. In addition, some plant-based alternatives to animal products may contain similar amounts of saturated fats and added sodium. Thus, as plant-based diets gain popularity, from the health perspective it is important to emphasize the overall quality of these eating patterns. Moreover, as with any eating pattern, fully plant-based diets should be well planned to ensure optimal nutrient intake, including vitamin B12.[663,664]

Spotlight: Plant-Based Lifestyle Medicine Program, NYC Health + Hospitals/Bellevue

Bellevue Hospital, in the Kips Bay neighborhood of Manhattan, launched a plant-based diet program in January of 2019 with the support of then-Brooklyn Borough President Eric Adams.[691] Called the Plant-Based Lifestyle Medicine Program, this resource is designed for patients with chronic diseases and conditions, such as type 2 diabetes, prediabetes, high blood pressure, heart disease, and health concerns related to obesity.[692] Adams was able to get the city to fund $400,000 into launching the program,[693] and it began with more than 260 patients.[694]

Participants in the program receive the attention of doctors, a registered dietitian, and a health coach, and each individual's program is designed to meet their specific goals and health needs.[695] As a lifestyle program, it focuses on more than just diet. There are six areas of lifestyle change that participants are supported through: "plant-based diet, physical activity, stress reduction, sleep health, social connections, and avoidance of risky substances such as tobacco."[696]



Many snack and convenience foods, including Fritos, Sour Patch Kids, and Oreos, are technically plant-based demonstrating that plant-based doesn't necessarily mean a food item is healthy.[697] These items are increasingly joined in the marketplace by other ultra-processed foods specifically designed as vegetarian and vegan alternatives to animal products.[698,699,700,701,702] Vegans and non-vegans alike can now reach for oat milk ice cream,[703] pea protein "eggs,"[704] and plant-based meat analogues or "fake" meats.[705,706] These alternatives often contain the same high levels of added sugar, saturated fat, and sodium as the animal-based foods they mimic and are also implicated in rising rates of obesity and other diet-related diseases.[707,708,709,710] As a result of the proliferation and popularity of these products, the term "junk food vegan" has been coined to refer to plant-based eaters who rarely consume whole vegetables, fruits, and grains.[711,712]

Food and lifestyle choices, specifically nutritious plant-based diets, can be effective in the management and treatment of disease. This does not discount or eliminate the use of medications or conventional therapeutics, which may also play a powerful role in managing disease and reducing the risk of disease-related complications. Additionally, when plant-based diets are used in conjunction with conventional therapeutics under the guidance and oversight of qualified healthcare professionals, it could lead to a powerful response to all disease.[713,714] In the modern "food as medicine" model, nutrition and medications can be applied together as appropriate to greatly enhance outcomes.[715,716]

Evidence-based approaches to food as medicine recognize that a fully plant-based diet may not be accessible/feasible for all patients.[717] Some individuals may lack the nutritional knowledge, access to fresh produce and plant-based foods, and/or cooking skills required to implement and maintain such a diet.[718,719] Others may face social and cultural barriers, including harsh criticism from friends and family members, that make going plant-based untenable for them.[720]

The perceived high cost of a plant-based diet may also be a deterrent, though recent research shows that many plant-based foods are less expensive per serving than red meats, poultry, eggs, and seafood.[721] Legumes, for example, are rich in protein and fiber and are among the most economical foods available. To address these and other barriers to adopting a plant-based diet, culturally sensitive education and support should be made readily available (e.g., to patients in health care settings) to increase their consumption of healthful plant-based foods, including fruits, vegetables, whole grains, legumes, nuts, and seeds. Changes in local and national food policies are also warranted to increase access to these foods in all communities. In the end, plant-based diets are tools that many people can implement to enhance their health outcomes, however, they are not necessarily a universal panacea.

Part II

Food as Medicine Challenges

PART II

Food as Medicine Challenges

Despite the long history of food as medicine across history and cultures, as well as its rise in popularity in our modern culture, there remain critical challenges throughout the food ecosystem that may limit the ability for "food as medicine" to be actualized in practice. This section highlights several of these challenges starting with controversies and inconsistencies surrounding dietary guidelines, followed by discussions of efforts to define the term "healthy;" food insecurity, food justice and health equity; insufficient nutrition counseling from clinicians; food marketing; and food industry-funded research. It is important to acknowledge and understand these challenges in order to develop, implement, and evaluate effective, long-term strategies and solutions.

The Impact and Influences of the Dietary Guidelines

The Dietary Guidelines for Americans

The impact of food and diet on health has been used to influence both national and international dietary guidelines intended to prevent and reduce diet-related diseases.[722,723] Every five years, the United States Department of Agriculture (USDA) and the Department of Health and Human Services (HHS) release updated Dietary Guidelines to help Americans make informed food and beverage decisions.

The 2020-2025 Dietary Guidelines for Americans promote nutrient-dense foods such as vegetables, fruits, and whole grains, and discourage overconsumption of foods high in added sugar, saturated fat, and sodium.[724] Although nutritious diets rich in whole foods have been proven to address chronic diseases and obesity, the diets of more than 80 percent of Americans do not meet the U.S. dietary recommendations.[725] Data from the Centers for Disease Control and Prevention (CDC) showed that only 12.2 percent of American adults met the standard for fruit intake and 9.3 percent for vegetables in 2015, and this rate is even lower among those living in poverty.[726]

The Dietary Guidelines are intended to "provide food-based recommendations to

promote health, help prevent diet-related chronic diseases, and meet nutrient needs;"[727] however, it's important to note that the dietary guidelines are not without criticism and controversy.[728,729] Governmental diet regulations are severely politicized and criticized because of their deep connections to corporate interests.[730]

For instance, the 2020 Dietary Guidelines Advisory Committee had multiple ties to industry, including the National Cattlemen's Beef Association, the American Beverage Association, the Academy of Nutrition and Dietetics, Atkins Nutritional, and more.[731,732] Furthermore, according to the *New York Times*, more than half of the committee has ties to the International Life Sciences Institute, a shadow "pro-sugar" group created in 1978 by a Coca-Cola executive.[733] This Institute has been described by the *New York Times* as "almost entirely funded by Goliaths of the agribusiness, food, and pharmaceutical industries,"[734] and presently includes companies such as DuPont, PepsiCo, Danone, and General Mills.[735]

For many years, food policy advocates and experts have raised concerns that the Dietary Guidelines Advisory Committee has failed to follow advancements in nutrition science, and often favors recommendations that benefit large food and beverage companies that have significant influence over the process of setting guidelines.[736] The food and beverage industry, including corporations and trade groups, spends considerable amounts of money lobbying Congress members to influence the federal government's nutrition standards in addition to local, state, and federal policies.[737] For instance, in 2018 and 2019, Mars Inc. spent more than $2 million on lobbying efforts related to food policy issues, including the Dietary Guidelines.[738] And in 2020, 28 members of Congress (who have no expertise in nutrition or medicine but presumably spoke to lobbyists or other industry representatives) sent a letter to Sonny Perdue and Alex Azar, former respective heads of the USDA and HHS, challenging the daily recommended alcohol limit for men.[739,740]

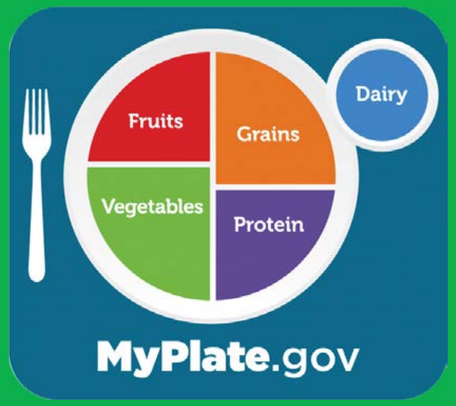
According to Marion Nestle, PhD, MPH, Paulette Goddard Professor of Nutrition, Food Studies, and Public Health, Emerita, at New York University and author of the books *Food Politics: How the Food Industry Influences Nutrition and Health* (Revised Edition) (University of California Press, 2013) and *Unsavory Truth: How Food Companies Skew the Science of What We Eat* (Basic Books, 2018):

> The USDA and the US Department of Health and Human Services (HHS) have issued Dietary Guidelines for Americans (DGAs) every five years since 1980. Because the DGAs influence federal nutrition policy and can affect sales of targeted foods and beverages, they are of intense interest to the food industry. The producers of foods high in saturated fat, sugars, and sodium lobby relentlessly against guidelines suggesting that the intake of meat should be reduced, for example. In response to industry pressures, the 1980 guidelines addressed meat intake only indirectly; they advised Americans to 'avoid too much fat, saturated fat, and cholesterol.'[741]

Furthermore, many experts also argue that the Dietary Guidelines for Americans and other sources of nutrition information are overly complicated and confusing to the average consumer.[742,743] A study published in the *Journal of the Academy of Nutrition and Dietetics* in 2013 determined that one of the core barriers to adherence to the Dietary Guidelines for Americans among adults was a "lack of knowledge of recommendation/portion/health benefits."[744] And a health policy brief

Spotlight: Dietary Guidelines for Americans 2020-2025 (USDA)

The core elements that make up a healthy dietary pattern include:



- Vegetables of all types—dark green; red and orange; beans, peas, and lentils; starchy; and other vegetables
- Fruits, especially whole fruit
- Grains, at least half of which are whole grain
- Dairy, including fat-free or low-fat milk, yogurt, and cheese, and/or lactose-free versions, and fortified soy beverages and yogurt as alternatives
- Protein foods, including lean meats, poultry, and eggs; seafood; beans, peas, and lentils; nuts, seeds, and soy products
- Oils, including vegetable oils and oils in food, such as seafood and nuts

The Guidelines recommend:

- Limiting added sugars* to less than 10 percent of calories per day for ages 2 and older and to avoid added sugars for infants and toddlers;
- Limiting saturated fat to less than 10 percent of calories per day starting at age 2;
- Limiting sodium intake to less than 2,300mg per day (or even less if younger than 14);
- Limiting alcoholic beverages* (if consumed) to 2 drinks or less a day for men and 1 drink or less a day for women.

To learn more about the Dietary Guidelines for Americans, see here.

** The Dietary Guidelines for Americans, 2020-2025 recommend limiting intake of added sugars and alcoholic beverages, but do not include changes to quantitative recommendations from the 2015-2020 Dietary Guidelines for these two topics, because the new evidence reviewed since the 2015-2020 edition is not substantial enough to support changes to the quantitative recommendations for either added sugars or alcohol.*

Spotlight: The “Cheeseburger Bill”

In 2002, an overweight man from New York filed a lawsuit against McDonald’s, alleging that the fast food chain was at fault for his obesity and diabetes. After this suit, many similar ones were filed across the country,[745] including a lawsuit filed by two Bronx teenagers against the McDonald’s Corporation alleging the fast-food giant was responsible for their obesity (the case was dismissed).[746,747]

Obesity lawsuits gained national media attention, and the executives at the fast-food and big-food industries took notice. One possible result of this attention is the Personal Responsibility in Food Consumption Act in 2004, colloquially known as the “Cheeseburger Bill.”[748] The bill was introduced by former Representative Ric Keller (R-FL). The law would have protected the food industry, particularly fast-food companies, from lawsuits brought by the public based on diet-related disease claims.[749] (It is worth noting that Representative Keller received nearly $60,000 from the Food & Beverage industry during his 2004 Congressional campaign.)[750] Former Representative Phil Gingrey (R-GA), a co-sponsor of the bill, said to Congress, “allowing an individual to sue a restaurant because the consumer chose to eat there often or chose to eat too much is simply ridiculous and, frankly, it is a dangerous waste of the court’s time. For every frivolous case that takes up a spot on the docket, a legitimate case where an individual is truly harmed and truly needs expeditious judicial review gets pushed farther and farther down the line.”[751]

The Personal Responsibility in Food Consumption Act was passed by the United States House of Representatives in 2004 and again in 2005, although was never brought to a vote in the Senate and thus never became law.[752] In 2009, a similar bill was introduced to the House, called the Commonsense Consumption Act.[753] This bill, similar in nature to the Cheeseburger Bill, “Prohibits new, and requires dismissal of pending, civil actions by any person against a manufacturer, marketer, distributor, advertiser, or seller of food, or a trade association, for any injury related to a person’s accumulated acts of consumption of food and weight gain, obesity, or any associated health condition.”[754] The Commonsense Consumption Act never made it to a vote on the House floor.[755]

Supporters of these bills claim that lawsuits against fast food companies for overconsumption are frivolous, and that the food industry should not have to be subject to them.[756] However, criticism centers around the argument that the courts themselves, not Congress, should decide if a lawsuit is frivolous or not.[757] Representative Jim McGovern (D-MA) said of the Cheeseburger Bill: “It is an unnecessary distraction from the real problems facing the American people.”[758] Another opponent of the bill, Representative Sheila Jackson-Lee (D-TX), said to Congress, “Having such a restrictive rule truly goes too far and limits the protections of the American people.”[759]

published in 2016 in the journal *Health Affairs* noted the confusion the guidelines create for the average American, stating that:

> While accessible to the layperson, the [Dietary Guidelines for Americans] are intended for policy makers and nutrition and health professionals, and they include ample footnotes citing numerous studies. There are also fourteen appendices, including one each on the three different food patterns and four on different food sources ranging from fiber to vitamin D. There are recommended amounts of different nutrients based on twelve different daily calorie needs, which are further subdivided by an individual's age, sex, and level of physical activity.[764]

The Dietary Guidelines for Americans promote the consumption of specific foods, such as fruits and vegetables, which is straightforward enough for consumers to understand. However, in the section about what to avoid, the guidelines do not provide a list of specific foods, but rather tell consumers to limit intake of certain nutrients, such as saturated fats, sodium, and sugars,[765] which requires individuals to have a knowledge about these nutrients and the foods and beverages that contain them. For instance, the Dietary Guidelines for Americans say, eat more fruits and less "saturated fats."[766] The average consumer can determine the difference between fruit from non-fruit, but may not be able to discern between different types of fat (saturated, unsaturated, trans).[767] In fact, according to a 2009 study appearing in *Annals of Nutrition and Metabolism* across 16 countries, most consumers do not even know what saturated fat is.[768]

The guidelines also state that consumers should limit their intake of added sugars.[769] However, this requires consumers to know which foods and beverages contain added sugar (e.g. cereals, yogurts, condiments, carbonated beverages, flavored milks, and sports drinks), but also to know the more than 60 names for sugar (e.g. sucrose, fructose, corn syrup, brown sugar, maple syrup, honey, fruit juice concentrate, and evaporated cane juice).[760,761]

By only listing nutrients to "avoid," the Dietary Guidelines for Americans places the onus on the consumer to know which nutrients are in which foods and beverages. Expecting all Americans to know exactly what foods contain saturated fats, sodium, or added sugars can complicate making informed decisions; instead, the Dietary Guidelines for Americans should educate the public about the foods they eat and their nutritional components.[762]

Dietary Guidelines from the World Health Organization

On a global level, the World Health Organization (WHO) also issues dietary guidelines, recognizing the role that a healthy diet has in preventing malnutrition and many chronic diseases. The WHO's guidelines promote eating whole foods such as vegetables, fruits, legumes, and whole grains, and recommend a limited consumption of added sugars, saturated fats, and sodium.[763] See a summary of the guidelines below:

Healthy Diet — World Health Organization

A healthy diet includes the following:

- Fruit, vegetables, legumes (e.g. lentils and beans), nuts and whole grains (e.g. unprocessed maize, millet, oats, wheat and brown rice).
- At least 400 g (i.e. five portions) of fruit and vegetables per day, excluding potatoes, sweet potatoes, cassava and other starchy roots.

- Less than 10 percent of total energy intake from free sugars, which is equivalent to 50 g (or about 12 level teaspoons) for a person of healthy body weight consuming about 2,000 calories per day, but ideally is less than 5 percent of total energy intake for additional health benefits. Free sugars are all sugars added to foods or drinks by the manufacturer, cook or consumer, as well as sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates.
- Less than 30 percent of total energy intake comes from fats. Unsaturated fats (found in fish, avocado and nuts, and in sunflower, soybean, canola and olive oils) are preferable to saturated fats (found in fatty meat, butter, palm and coconut oil, cream, cheese, ghee and lard) and trans-fats of all kinds, including both industrially-produced trans-fats (found in baked and fried foods, and pre-packaged snacks and foods, such as frozen pizza, pies, cookies, biscuits, wafers, and cooking oils and spreads) and ruminant trans-fats (found in meat and dairy foods from ruminant animals, such as cows, sheep, goats and camels). It is suggested that the intake of saturated fats be reduced to less than 10 percent of total energy intake and trans-fats to less than 1 percent of total energy intake. In particular, industrially-produced trans-fats are not part of a healthy diet and should be avoided.
- Less than 5 g of salt (equivalent to about one teaspoon) per day. Salt should be iodized.
- To learn more about the World Health Organization's guidelines for a healthy diet, see here.

According to a study published in *The Lancet* which looked at the "consumption of major foods and nutrients across 195 countries and quantified the impact of their suboptimal intake on [non-communicable disease] mortality and morbidity," from 1990-2017, consumption of almost all nutritious foods (nutrient-dense foods such as fruits, vegetables, whole grains, and lean proteins) and nutrients are below the recommended levels.[770] Simultaneously, the daily intake of unhealthy foods and nutrients are higher than the recommended level, with the consumption of sugar-sweetened beverages being far higher than the optimal level at 49 grams per day[771] (the American Heart Association recommends a daily sugar intake in the United States of 37 grams for men, 25 grams for women,[772] and less than 25 grams for children ages 2-18[773]). The consumption of processed meat, red meat, and sodium exceed recommended levels as well, which is considered unhealthy according to study researchers.[774] In general, men have a higher intake of both "healthy and unhealthy foods" than women; intake of healthy and unhealthy foods are highest among adults aged 50-69 years, and lowest among adults aged 25-49 years; and sugar-sweetened beverages and legume consumption are highest among young adults and decreased with age.[775]

In addition to the negative impact that unhealthy foods such as red meat and processed meat can have on health, the study also reported that there is mounting evidence that has emerged over the past decade demonstrating that shifting diet from animal-based to plant-forward (e.g. fruit, vegetables, and whole grains) might be associated with lower greenhouse gas emissions, thereby making it more environmentally sustainable.[776]

The WHO notes that the exact composition of a healthy, well-balanced diet will vary not only among age, gender, degree of activity, and lifestyle, but also among different cultures, dietary customs, and the availability and affordability of nutritious foods.[782] In many low-income countries, nutritious diets can be unaffordable for the average household, thus impacting consumption.[783] This problem was described in the 2020 Global Nutrition Report:

> For consumers to be able to purchase and consume healthy foods that are available within the food environment, such foods need to be affordable. For the most vulnerable groups of the population, nutrient-rich foods such as animal-source foods, fruits and vegetables are not affordable. Both price levels and volatility affect household purchasing power, welfare and food security, and nutrition.[784]

These data highlight the critical need to both understand and address other key factors influencing healthy food consumption. Evidence-based dietary guidelines alone cannot improve healthy diets and address the burden of diet-related diseases.[785]

In 1963, the WHO and the Food and Agriculture Organization of the United Nations (FAO) established the Codex Alimentarius Commission (CAC). The WHO and FAO tasked the CAC with developing a joint FAO/WHO food standards program and creating the Codex Alimentarius, "a collection of standards, guidelines and codes of practice" that protect the safety, quality, and fairness of food traded internationally.[786,787] The Codex is a reference guide, with no regulatory authority or enforcement abilities.[788] The CAC is composed of 189 member states,[789] and meets multiple times per year to ensure all Standards, Guidelines, and Codes of Practice are up-to-date and backed by "sound scientific evidence."[790]

Dietary Guidelines Around the World

In addition to the WHO's global nutrition recommendations and guidelines mentioned above,[777] many countries around the world have their own national dietary guidelines and recommendations, catered to the cultures, eating habits, and food availability that they represent.[778] The Food and Agriculture Organization of the United Nations (FAO) notes that dietary guidelines "provide advice on foods, food groups and dietary patterns to provide the required nutrients to the general public to promote overall health and prevent chronic diseases."[779] A study published in 2016 in the journal *Advances in Nutrition* stated that "dietary guidelines provide evidence-based statements on food choices to meet nutritional requirements and reduce the risk of prevailing chronic disease. They involve a substantial amount of research translation, and their implementation has important health consequences."[780] Therefore, dietary guidelines can be used in food as medicine interventions by providing research that can help healthcare professionals craft individually-tailored dietary recommendations. Additionally, dietary guidelines attempt to promote good health through diet, which can help reduce the prevalence of diet-related diseases.

Eat For Health: Australian Dietary Guidelines[781]

The five guidelines:

- To achieve and maintain a healthy weight, be physically active and choose amounts of nutritious food and drinks to meet your energy needs.
  - Enjoy varied foods from five major food groups every day. The five groups are vegetables and legumes, fruits, grains and cereals, lean meats and other proteins, and dairy products.
  - Drink plenty of water.

- Limit intake of foods containing saturated fat, added salt, added sugars and alcohol.
  - Replace foods containing saturated fats with those containing predominantly monounsaturated and polyunsaturated fats.
  - Do not add salt to food while cooking or at the table.
  - Limit intake of sugar-sweetened beverages.
  - Limit alcohol consumption.
- Encourage, support and promote breastfeeding.
- Care for your food; prepare and store it safely.

The Australian government also released an Aboriginal and Torres Strait Islander Guide to Healthy Eating, with visuals catered to these historically underserved populations.[791] To learn more about the Australian guidelines, see here.

Dietary Guidelines for the Brazilian Population[792]

- Five principles:
  - Diet is more than the intake of nutrients.
  - Dietary recommendations need to be tuned to their times.
  - Healthy diets derive from social and environmentally sustainable food systems.
  - Different sources of knowledge inform sound dietary advice.
  - Dietary guidelines broaden autonomy in food choices.
- Recommendations to consumers making food choices:
  - Make natural or minimally processed foods the basis of your diet.
  - Use oils, fats, salt, and sugar in small amounts for seasoning and cooking foods and to create culinary preparations.
  - Limit the use of processed foods, consuming them in small amounts as ingredients in culinary preparations or as part of meals based on natural or minimally processed foods.
  - Avoid ultra-processed foods.
  - The “golden rule”: Always prefer natural or minimally processed foods and freshly made dishes and meals to ultra-processed foods.
- There is no food guide, instead there are multiple examples of well-rounded and culturally appropriate meals.
- To learn more about the Brazilian guidelines, see here.

Canada's Food Guide Healthy Food Choices[794]

Make it a habit to eat a variety of healthy foods each day.

- Eat plenty of vegetables and fruits, whole grain foods and protein foods. Choose protein foods that come from plants more often.
  - Choose foods with healthy fats instead of saturated fat.
- Limit highly processed foods. If you choose these foods, eat them less often and in small amounts.
  - Prepare meals and snacks using ingredients that have little to no added sodium, sugars or saturated fat.
  - Choose healthier menu options when eating out.
- Make water your drink of choice.
  - Replace sugary drinks with water.
- Read and compare food labels while shopping.
- Be aware that food marketing can influence your choices.
- To learn more about the Canadian guidelines, see here.

Chinese Dietary Guidelines[793]

- The Food Guide Pagoda, with amounts of each category decreasing from base to top:
  - Cereals, tubers, and legumes at the base.
  - Fruits and vegetables on level 2.
  - Lean meats, fish, and eggs on level 3.
  - Dairy products, soybeans, and nuts on level 4.
  - Salt and cooking oil on level 5.
- A typical diet should consist of cereals and tubers, fruits and vegetables, lean meats, dairy products, soybeans, legumes, and nuts.
- At least 50 percent of total energy intake should be from carbohydrates.
- Variety is important: eat at least 12 different foods each day, and 25 each week.
- Perform moderate physical exercise for at least 150 minutes each week.
- Prioritize fresh lean meats, such as fish and poultry, over fatty meats and smoked or cured meats.
- Limit table salt, cooking oil, added sugar, and alcohol.
  - Recommended sugar intake of less than 50g per day.
- Drink 7-8 cups of water daily.
- Avoid food waste wherever possible.
- To learn more about the Chinese guidelines, see here.

Spotlight: Traffic Light Food Labeling

Various countries across the world have passed "traffic light" food labeling laws. These labels attempt to help consumers determine the healthiness of various products with a clear visual aid.[795] Traffic light labels range from green-yellow-red (green is best, red is worst) to determine the healthfulness of a product based on a variety of factors, which might include sodium, added sugar, saturated fat, calories, and more. Countries that have adopted traffic-light labeling practices include Ecuador,[796] the United Kingdom,[797] and Sri Lanka.[798] Furthermore, the Department of Education in the state of Western Australia uses a traffic light system to determine if certain foods are allowed in the cafeterias.[799]

Studies about the effectiveness of traffic-light labels have mixed results; generally, consumers notice the labels and are aware of what they mean.[800,801,802,803] However, this awareness does not always translate to changes in purchasing habits.[804,805] Furthermore, alternative labeling practices have proven to be more effective at altering purchasing habits, such as France's Nutri-Score system[806,807] and warning labels.[808] While somewhat impactful, in a 2019 study of consumer habits regarding traffic light labels vs. brand identification, researchers found that consumers are more likely to trust a brand with which they are already familiar and disregard any information on the traffic-light label.[809]

Kenya's National Guidelines for Healthy Diets and Physical Activity[810]

Kenya's Guidelines acknowledge that the country is burdened with three dietary issues simultaneously: malnutrition, overnutrition, and undernutrition. Hunger persists even as overweight and obesity rates increase.

- Educational material about many aspects of food, including:
  - Macro- and micronutrients, the dietary sources of these nutrients, and the functions they play in the body.
  - Food preparation and processing techniques.
  - Types of foods and their nutritional attributes.
- Nine key guidelines to a healthy diet:
  - Eat a variety of foods from different food groups every day. Include whole or unprocessed starchy foods as part of meals.
  - Eat plenty of green leafy vegetables, red and yellow vegetables and fruits every day; and include a variety of other vegetables and fruit.
  - Eat beans, peas, lentils, cowpeas, pigeon peas, soya, nuts and edible seeds regularly (at least four times a week).
  - Eat lean meat, fish and seafood, poultry, insects or eggs at least twice a week.
  - Drink fresh milk, fermented milk or yoghurt every day.
  - Use oil or fat in moderation in meals; limit the amount of solid fat. Use fortified oil.
  - If you use sugar, use it sparingly.
  - Use iodized salt, but use it sparingly.
  - Drink plenty of safe water.
- Physical activity is recommended for all people at all stages of life.

Dietary and physical activity recommendations are further specified based on life state, including infants, children, adolescents, adults, older adults, and pregnant or lactating people. To learn more about the Kenyan guidelines, see here.

The Norwegian Dietary Guidelines[811]

- Enjoy a varied diet with lots of vegetables, fruit and berries, whole-grain foods and fish, and limited amounts of processed meat, red meat, salt and sugar.
- Maintain a good balance between the amount of energy you obtain through food and drink and the amount of energy you expend through physical activity.
- Eat at least five portions of vegetables, fruit and berries every day.
- Eat whole grain foods every day.
- Eat fish two to three times a week. You can also use fish as a spread on bread.
- Choose lean meat and lean meat products. Limit the amount of processed meat and red meat.
- Include low-fat dairy foods in your daily diet.
- Choose edible oils, liquid margarine and soft margarine spreads instead of hard margarines and butter.
- Choose foods that are low in salt and limit the use of salt when preparing food and at the table.
- Avoid foods and drinks that are high in sugar.
- Choose water as a thirst-quencher.
- Be physically active for at least 30 minutes each day.
- To learn more about the Norwegian guidelines, see here.

Singapore's How to Eat Right to Feel Right[812]

- The eight Dietary Guidelines for Adult Singaporeans (18 to 69 years):
  - Enjoy a variety of food using some healthy guidelines.
  - Achieve and maintain body weight within the normal range.
  - Eat sufficient amounts of grain, especially whole grains.
  - Eat more fruits and vegetables every day.
  - Choose and prepare food with less fat, especially saturated fat.
  - Choose and prepare food with less salt and sauces.
  - Choose beverages and food with less sugar.
  - If you drink alcoholic beverages, do so in moderation.
- These guidelines are accompanied by the resource, Build a Healthy Diet Meal Plan.
  - In one day, adult Singaporeans are recommended to eat 5-7 servings of whole grains, 2 servings of fruit, 2 servings of vegetables, and 2-3 servings of meat, dairy, or others.
  - Choose healthier oils and unsaturated fats.
  - Avoid or minimize alcohol.
- To learn more about the Singaporean guidelines, see here.

Swedish National Food Agency Recommendations[813]

- Slogan: "Find your way to eat greener, not too much and be active!"
- More fruits and vegetables:
  - Maintain variety in types of vegetables as well as cooking style.
  - Always have frozen vegetables available at home.
  - Make sure vegetable choices are seasonal.
- More seafood:
  - Choose many different types of fish and shellfish in many different ways.
  - Mussels are particularly eco-friendly.
  - Be aware of certain fish that might contain pollutants.
- More exercise:
  - Choose to bike instead of drive, or take the stairs instead of the elevator.
  - Exercise for at least 30 minutes per day, every day.
- Dietary switches to make:
  - Whole grains.
  - Healthy fats.
  - Low fat dairy products.
- Things to avoid:
  - Red and processed meats.
  - Excessive salt.
  - Added sugar.
- "The Keyhole" is a National Food Agency symbol printed on packaged foods that have less salt and sugar, and more whole grains and healthy fats.
- To learn more about the Swedish guidelines, see here.

The United Kingdom's Eatwell Guide[814]

- The visual Eatwell Guide is shaped like a circle.
  - One third is dedicated to fruits and vegetables.
  - One third is dedicated to starchy carbohydrates, such as potatoes, pasta, bread, and rice.
  - About a sixth is dedicated to protein-dense foods, such as meat, fish, and beans.
  - Just under a sixth is dedicated to dairy products and dairy alternatives.
  - A tiny sliver is dedicated to oils and spreads.
- Nutrient recommendations:
  - 2250 kcal per day.
  - At least 50 percent of energy intake from carbohydrates.
  - Less than 5 percent of energy intake from free sugars.
  - Less than 35 percent of energy intake from saturated fats.
  - Approximately 15 percent of energy intake from proteins.
  - About 30g of fiber per day.
  - Less than 6g of salt per day.
- Food recommendations:
  - At least 5 portions of fruits and vegetables per day.
  - At least 2 portions of fish per week, one of which should be oily fish.
  - Less than 70g of red meat per day.
- Drink 6-8 cups of water per day.
- To learn more about the UK's guidelines, see here.

An Attempt to Define the Terms "Healthy" and "Unhealthy"

Common advice given to individuals seeking to improve their health is to "eat healthy" or to keep up a "healthy diet." But what, exactly, are "healthy foods"? "Healthy" or related terms (such as "health," "healthful," "healthfulness," "healthfully," "healthier," "healthiest,"

Spotlight: Healthy Eating Defined and Deconstructed by Charles Platkin, PhD, JD, MPH[815]

The term "healthy eating" is mentioned all the time — in the media, by academics, government discussions, social settings, and almost everywhere you go when health is discussed. The problem is that the term probably has hundreds if not thousands of definitions. I once asked a class full of nutrition students to define the term, and their responses were amazing. They used words and phrases such as "balanced," "moderation," "good for you," "no GMOs and organic," "filled with nutrients," and "nutritious." However, many of those definitions need definitions themselves. Very confusing. I decided to reach out to some of the world's experts on health and nutrition to find some answers. Here is what I found:

Colin Campbell, Jacob Gould Schurman Professor Emeritus of Nutritional Biochemistry at Cornell University, co-author of *The China Study* and Founder of nutritionstudies.org
"Healthy eating and/or the term nutrition is the biological expression of food that creates health for individuals, for society and for the planet. Health is provided by a variety of plant-based foods composed of countless nutrients and nutrient-like substances acting "wholistically," from consumption and digestion to tissue function, and is best obtained by consuming whole foods, not individual nutrients derived therefrom.

The effects of eating this way are exceptionally broad, simultaneously maintaining health and preventing and treating a broad range of illnesses and diseases. Healthy eating should not only be taught in medical schools but should also be a medical specialty, which would allow the practitioners to be reimbursed for services."

David L. Katz, MD, MPH, author of *The Truth about Food*. and founder of True Health Initiative
"To me, 'healthy' does NOT mean changing weight as fast as possible. It means fostering vitality and longevity; adding years to life and life to years. And since there can be no truly healthy people on a sick and ravaged planet, it also means sustainable – friendly to the planet, the climate, to biodiversity, to the permafrost and the rain forests. Aggregate the massive available information we have on these topics from diverse sources- from science, sense, and the global consensus of expert – and you get a very clear articulation of the theme: a diet made up MOSTLY of minimally processed vegetables, fruits, whole grains, beans/legumes, nuts and seeds, with plain water the go-to answer for thirst. Get those fundamentals right – wholesome foods in a balanced, sensible assembly – and you simply can't go too far wrong!"

Marion Nestle, PhD, Professor, of Nutrition, Food Studies, and Public Health Emerita at New York University and author of *How Food Companies Skew the Science of What We Eat*
"What 'healthy eating' is turns out to be so simple that the journalist Michael Pollan can do it in seven words: "Eat food. Not too much. Mostly plants." Really, that's all there is to it. Those seven words reflect plenty of evidence that diets that follow these principles–a wide variety of relatively unprocessed foods (including many of plant origin) in amounts that balance calorie intake with expenditure–are associated with prevention of weight gain and the chronic diseases for which it is a risk factor. What I like so much about these principles is that they provide plenty of room for enjoying food as one of life's greatest pleasures."

Urvashi Rangan, PhD, Chief Science Advisor, GRACE Communications Foundation and Founder of FoodPrint.org
"How ingredients are produced and processed and packaged all impact the health of our eating. Pesticides, chemicals, drugs, heavy metals, many food additives and aids won't be found on the label when they are used. Supporting food choices from progressive, biodynamic, regenerative, pasture-based or real organic food producers is a powerful way to support real sustainable and healthy food choices."

"healthiness," and "healthily") have been defined by the United States Food & Drug Administration (FDA) since 1993 with primary reference to total fat content.[816] Changes were made in 2016 to differentiate between different types of fat.[817,818,819] To be defined as "healthy" today, foods must be low in total fat, but also low in saturated fat, meet certain cholesterol and sodium specifications, and provide at least 10 percent of the recommended daily intake of protein, fiber, and certain vitamins or minerals, such as Vitamin A, Vitamin C, calcium and iron.[820,821] It is important to note that nutrient criteria used to define what is "healthy" varies among different food categories, including fruits, vegetables, seafood, and meat.[822]

However, the term "healthy" still creates confusion for many people.[823,824] In a 2018 survey of more than 1,000 American adults, about 15 percent said that if a food was labeled "healthy," they could eat as much of it as they wanted; approximately 40 percent said that the label healthy means they at least should eat more of this type of food; and approximately 35 percent said a healthy label would mean nothing to them.[825] Meanwhile, nearly all those surveyed said that fresh vegetables were healthy.[826]

While there was an overall consensus in the survey around defining vegetables as healthy, there was less consensus about what it means to eat healthy and make healthy food choices,[827] suggesting that terms like "healthy" and "unhealthy" are potentially confusing for average people. Furthermore, food that is called "healthy" is often perceived by consumers as less tasty, more expensive, or more difficult to find than food that is "unhealthy."[828,829,830,831] Redefining the term "healthy" and educating consumers about what the term means is critical because the perceived healthfulness of food products, whether through a label, educational campaign, or lifelong belief, can have a large influence on the dietary decisions consumers make.[832,833]

Food Insecurity, Food Justice, and Health Equity

Food insecurity is defined by the USDA as "a household-level economic and social condition of limited or uncertain access to adequate food"[834] and is associated with an increased risk of diet-related diseases.[835] Food insecurity plays a significant role in the prevalence and treatment of diseases, and their associated health outcomes.[836,837,838] Many underserved communities suffer disproportionately from obesity, heart disease, diabetes, and asthma as a result of food insecurity and diets lacking in nutrient-dense food.[839] A 2021 review of recent research published in *Current Nutrition Reports* noted a strong correlation between food insecurity and risk factors for cardiometabolic conditions (which include but are not limited to obesity, hypertension, diabetes mellitus, and heart failure)[840] among adults.[841] Reducing food insecurity is critical to improving health.[842] Food as medicine programs and interventions designed not only to reduce food insecurity but to also increase access to nutritious foods such as fruits and vegetables have been successful in improving health among food insecure populations.[843,844]

In addition to reducing food insecurity and improving health, these food as medicine programs and interventions, such as nutrition incentive programs[845] and medically tailored meals,[846] help ensure that vulnerable populations have access to fresh, nutritious foods. Promoting access to nutritious foods is a core component of food justice; while the definition may vary, food justice may be defined as "'the struggle against racism,

exploitation, and oppression taking place within the food system that addresses inequality's root causes both within and beyond the food chain."[847,848] These structural barriers include race and class, among others, as food insecurity disproportionately impacts racial and ethnic minorities as well as low-income individuals and families.[849,850,851,852,853] An analysis completed by the USDA of food insecurity trends from 2001 to 2016 found that the rates for both non-Hispanic Black and Hispanic households were at least twice that of non-Hispanic White households. [854] The burden of obesity and complications from conditions such as heart disease,[855,856] stroke,[857,858] type 2 diabetes,[859,860] and multiple types of cancer[861] are also higher among Black and Brown communities than White communities.[862,863,864]

Furthermore, communities of color and low-income communities often have limited access to nutritious food[865] and more frequently live in areas referred to as food deserts, which are defined by the USDA as areas with limited access to affordable and healthy food.[866] Black and Hispanic neighborhoods have fewer large supermarkets with fewer nutritious options than White neighborhoods, regardless of the community's income level.[867] A study in *Preventive Medicine* examined data from the 2000 US Census and 2001 InfoUSA food store data and determined that both the poverty level and the racial composition of a neighborhood impacted access to nutritious food, and "[p]oor predominantly black neighborhoods face a double jeopardy with the most limited access to quality food."[868]

Individuals without access to affordable nutritious foods often have to settle for cheaper, high-calorie alternatives that are more readily available in their communities, which directly impacts the prevention and treatment of disease.[869] Local, state, and national policymakers have, therefore, turned their attention to equalizing access to nutritious food as a means of improving public health.[870,871,872] For example, efforts have been made to incentivize convenience stores and bodegas to sell more nutrient-rich foods,[873] expand street produce-cart programs,[874] and improve school lunch food by offering more nutritious options and universal free breakfast and lunch, which is a key source of nutrition for many children from low-income families.[875]

In addition to improving access to nutritious food, some legislation attempts to limit access to unhealthy foods; this includes laws that target the fast-food industry and the commercial food sector.[876,877,878,879] In 2008, New York City became the first U.S. jurisdiction to mandate calorie-labeling on chain restaurant menus.[880] In 2015, the FDA ruled that food manufacturers would have to eliminate artificial trans fats from their products by 2018.[881] However, many barriers, including a lack of coordination amongst policymakers attempting to improve food access, still impede access to healthy food for all communities.[882,883]

Municipal and federal governments are not the only stakeholders taking a greater interest in food justice and health equity. Food justice advocates continue to pressure the federal government to cut subsidies for sugar and corn.[884,885,886] These cuts would increase the price of the processed foods and soda that the crops are used to create, potentially severing the link between low-income consumers and nutrient-poor diets.[887] In addition, the United Nations (UN) includes "Zero Hunger" as one of its 17 Sustainable Development Goals (SDGs), with core tenets of "food security and improved nutrition."[888] The connections between food, disease, and health equity within communities around the globe are a growing area of scientific, political, and moral interest.[889,890,891]

Changing how researchers, policymakers, and advocates define and refer to communities that lack access to nutritious foods (e.g. food deserts) is critical in taking a more ecological approach to address food insecurity. This approach includes examining what current resources, skills, and efforts already exist in these neighborhoods. Additionally, redefining terms such as “food desert” is important for designing food as medicine interventions and programs to improve access to nutritious, fresh foods. While the term “food desert” is used widely to describe communities and neighborhoods lacking access to fresh foods, many studies and activists argue that “food desert” is an inaccurate term, because it conceals the vibrant life and food systems in these communities and implies that, like actual deserts, these areas are naturally occurring.[899] The term may also be considered misleading because it draws focus away from the underlying causes of lack of access to healthy food.[900] In an interview with art and politics magazine *Guernica*, food justice advocate Karen Washington argued that instead of using the term “food desert,” we should use “food apartheid” because:

> ...food apartheid looks at the whole food system, along with race, geography, faith, and economics. You say ‘food apartheid’ and you get to the root cause of some of the problems around the food system. It brings in hunger and poverty. It brings us to the more important question: What are some of the social inequalities that you see, and what are you doing to erase some of the injustices?[901]

Using the term “food apartheid” to address food justice disparities calls for an approach to the food system that acknowledges the role of race and class as well as geography and economics.[902]

Access to nutritious food is a critical component of food justice,[903] as well as the emerging field of health equity.[904] According to the CDC, health equity is achieved:

> ...when every person has the opportunity to “attain his or her full health potential” and no one is “disadvantaged from achieving this potential because of social position or other socially determined circumstances.” Health disparities or inequities are types of unfair health differences closely linked with social, economic, or environmental disadvantages that adversely affect groups of people.[892]

Increasing evidence has demonstrated that individuals living in low-income and underserved communities are disproportionately impacted by diet-related disease and chronic health conditions.[893] Health equity advocates argue that these health disparities are not incidental[894] but are the product of systemic social inequalities such as racism, classism, and sexism.[895] Given that nutritious food is a critical component of a healthy life,[896] health equity overlaps significantly with food justice, which seeks to understand how these systemic social inequalities impact the food system and access to nutritious food.[897]

Food Insecurity and Food as Medicine Interventions

Food as medicine interventions, such as medically tailored meals, medically tailored groceries, and produce prescription programs, have demonstrated positive outcomes in reducing food insecurity and improving health.[898] According to an analysis in the journal *BMJ*:

> Referring patients to food is medicine interventions can change their ability to follow dietary recommendations, tackling several barriers to healthy eating, including the inability to afford or access recommended foods. Providing food or food focused financial assistance can also alleviate budget constraints that prevent patients from affording medications and paying bills. Some food is medicine

interventions model appropriate portion size and ingredient selection, enabling recipients to maintain more healthful diets past the intervention duration. Clinicians who refer patients to food is medicine interventions might also see better disease management and fewer admissions to hospital. A patient with diabetes who typically runs out of food when monthly assistance is exhausted, for example, could be given anticipatory nutrition guidance and vouchers for supplemental food to avoid an episode of hypoglycaemia.[905]

Another 2019 study in the *Journal of General Internal Medicine* reported improved dietary quality and reduced hypoglycemia among food insecure adults with diabetes who were receiving medically-tailored meals.[906]

Food insecurity for low-income individuals and families is often compounded and shaped by many overlapping issues, such as lack of affordable housing, chronic or acute health problems, high medical costs, social isolation, low wages, and unemployment.[907] These types of issues are called "social determinants of health," defined as the social, physical, and economic conditions where people live, go to school, work, and play that influence their health.[908,909] There is a growing body of research and acceptance among academics, advocates, and healthcare professionals that health outcomes and disparities are more frequently driven by these social determinants, such as food insecurity and access to adequate nutrition, than by medical care alone.[910,911]

Poverty and food insecurity, which are closely related,[912] correlate with some of the most serious and costly health problems in the United States.[913,914,915] In a study of patient admissions from 2000-2008 published in *Health Affairs*, researchers found that risk for hypoglycemia admission increased at the end of the month, when food budgets were depleted.[916] The authors noted that "policy solutions to improve stable access to nutrition in low-income populations and raise awareness of the health risks of food insecurity might be warranted."[917]

Food insecurity and access to nutritious food were urgent problems before the pandemic, impacting 13.7 million Americans in 2019.[918] During the COVID-19 pandemic, food insecurity has increased significantly[919,920] and is now one of the most prominent health crises and health equity challenges in the United States, impacting as many as one in four Americans.[921,922] Many families experiencing poverty and food insecurity rely on low-cost foods, which are often unhealthy and low in nutrition, and exacerbate chronic conditions such as obesity, cardiovascular disease, diabetes, and hypertension.[923] It should also be noted that those with increased risk factors for cardiometabolic conditions are also at increased risk for adverse health outcomes, hospitalization, and death from COVID-19.[924]

However, not as many older adults enroll in SNAP as are eligible.[925] There are many administrative barriers to participating in SNAP that can be difficult for older adults to overcome, such as complicated recertification processes and processing delays.[926] In a 2021 study of 5,093 older adults enrolled in SNAP in North Carolina, researchers determined that participation was associated with fewer inpatient admissions and lower health care costs.[927] Yet, SNAP participation among eligible older adults is less than 50 percent.[928] Craig Gundersen, PhD, the Snee Family Endowed Chair at the Baylor Collaborative on Hunger and Poverty, called this an "important study," noting that food banks have the potential to help older adults enroll in SNAP, indirectly helping them keep medical costs down.[929]

Improved food security and nutritious food access can have a significant impact on health

Spotlight: New York City "Health Bucks"

In 2005, the New York City Department of Health began issuing Health Bucks, which are $2 coupons that can be used to purchase fresh fruits and vegetables at any of New York City's farmers' markets.[930] Since Health Bucks were first distributed they have been used to purchase more than $5 million worth of fresh fruits and vegetables at farmers' markets across the city.[931] Each year, community organizations (including faith-based organizations) can apply to receive Health Bucks, which they then distribute to members in an effort to encourage knowledge about nutrition and access to fresh produce.[932]

In addition to those distributed by community organizations, there are other ways for people to acquire Health Bucks. People who receive any kind of food assistance money, including SNAP and P-EBT, receive Health Bucks as a bonus when they use their EBT cards at farmers' markets in the city.[933] For every $2 spent at the market, individuals receive a $2 match in Health Bucks, capped at $10 per day.[934] Markets that accept EBT include GrowNYC's Greenmarkets, Farmstands, and Fresh Food Box sites,[935,936] and, taken together, they distributed $616,820 in Health Bucks in 2020 alone.[937] This was approximately two-thirds of all the Health Bucks distributed in NYC that year,[938] making GrowNYC the largest single distributor of Health Bucks in the city.

Prior to 2021, residents could receive Health Bucks through a program called Pharmacy to Farm Prescriptions. SNAP-receiving individuals with high blood pressure were able to receive $30 in Health Bucks when they filled their medication prescriptions at participating pharmacies.[939] This program began in 2017, and expanded to include 15 pharmacies across Manhattan, Brooklyn, and Queens.[940] By 2019, the program had enrolled more than 1,000 participants and distributed more than $85,000 worth of Health Bucks.[941]

outcomes and health care costs, and food-based government policies are needed to enable these improvements at a national-level. In fact, in the United States, SNAP has been successful in reducing food security for more than 50 years.[949,950,951] In August 2021, the administration of President Joe Biden revised the nutrition standards of SNAP, prompting an increase of more than 25 percent to average benefits—the largest permanent increase to benefits in the program's history.[952] Prior to this increase, SNAP benefits had not been permanently increased since 2006.[953] This increase will provide beneficiaries with more money to afford nutritious food, as most participants in the program exhaust their benefits before the end of the month.[954]

Nutrition Incentive Programs Increase Vegetable and Fruit Consumption Improving Health Outcomes

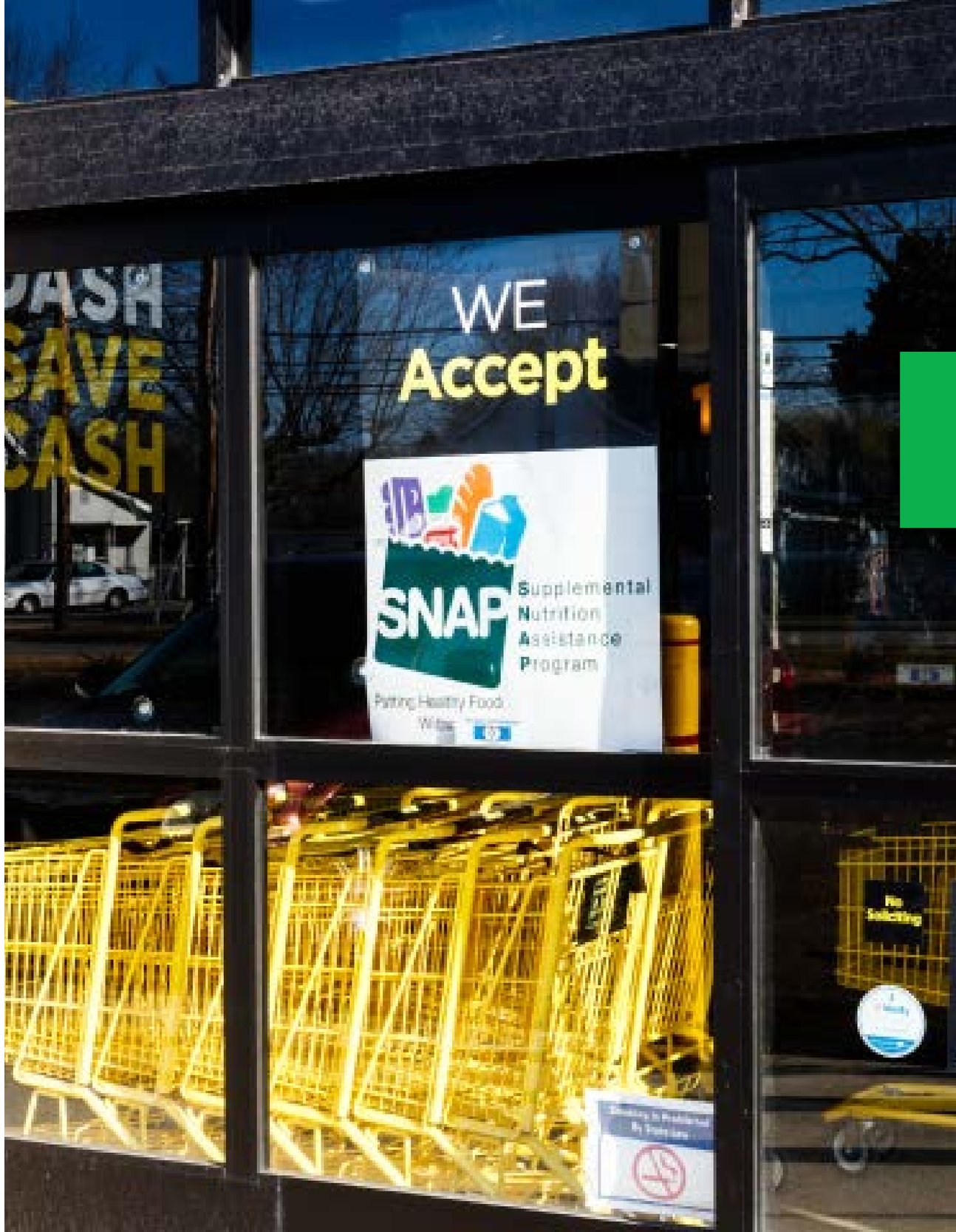
Federal food assistance programs such as SNAP have been shown to significantly reduce food insecurity.[955] However, many SNAP users have reported difficulty in accessing and affording nutritious foods, and consumption of fruits and vegetables in SNAP households remains significantly below recommendations in the Dietary Guidelines for Americans.[956,957] One promising approach to addressing these nutritional deficits are nutrition incentive programs, which are designed to improve access to fruits and vegetables among low-income populations by reducing the cost burden of these foods.[958,959] Many of these programs work by providing socioeconomically disadvantaged people with more purchasing power to be used on fresh produce.[960,961] This increased purchasing power is offered in the form of rebates, coupons, vouchers, matching SNAP funds spent on produce at farmers' markets, or other cash equivalents that can be used to purchase fruits and vegetables.[962]

The Gus Schumacher Nutrition Incentive Program (GusNIP, formerly known as the Food Insecurity Nutrition Incentives [FINI] Program), is a USDA food insecurity incentive program named for Gus Schumacher, who was a pioneer in advocating for increased consumption of fresh fruits and vegetables among participants in food assistance programs such as SNAP.[942,943] According to the USDA:

> The GusNIP grant program presents the opportunity to bring together stakeholders from various parts of the food and health care systems to foster understanding of how they might improve the health and nutrition status of participating households 1) receiving incentives through the purchase of fruits and vegetables, 2) prescribed fresh fruits and vegetables in addition to nutrition educational opportunities, and 3) offer incentive program training and technical assistance to applicants and grantees, facilitating growth in states with low participation, and collecting and aggregating core data sets from eligible entities through a central system to capture program success and identify best practices and areas to improve on a broad scale.[944]

GusNIP includes produce prescription programs for which doctors prescribe fruits and vegetables, usually for a reduced price, to improve health outcomes during routine visits.[945]

Research has demonstrated that produce prescription programs can improve local fruit and vegetable consumption, nutrition knowledge, and food purchasing practices.[946,947] One 2020 study appearing in *Current Developments in Nutrition* assessed the impact of a fruit and vegetable prescription program on the health outcomes and behaviors of Navajo children aged six and under. [948] Native American and Alaska Native populations were found to have higher than average childhood obesity rates, and food insecurity is a significant component



of this disparity. A local nonprofit teamed up with local healthcare providers to launch the Navajo Fruit and Vegetable Prescription (FVRx) Program with the aim of addressing the high childhood obesity rates among this population. At the conclusion of the six month program, participants reported a significant decrease in food insecurity (from 82 percent to 65 percent), and 38 percent of children previously categorized as overweight or obese had achieved a healthy BMI.[963]

GusNIP also includes Double Up programs, which provide funds to SNAP recipients to increase or match government nutrition benefits and enable low-income families to buy more fresh fruits and vegetables (and sometimes other healthy foods) at local markets.[964,965] For instance, the Double Up Food Bucks program in Iowa provides $1 in Double Up Food Bucks for every $1 spent by SNAP users on fresh fruits and vegetables for up to $10 per day.[966] In New York City, the Get the Good Stuff program, launched in 2019, allows SNAP users to purchase eligible fruits, vegetables and beans and receive $1 on a program loyalty card for every $1 they spend at four participating supermarkets, capped at $50.[967] The Health Bucks program, also in New York City, offers $2 in Health Bucks (which can be used to purchase fresh fruits and vegetables) for every $2 spent at farmers' markets using SNAP for up to $10 per day.[968] Finally, the Washington State Food Insecurity Nutrition Initiative offers SNAP recipients cash-value matching at farmers' markets; a 30 percent discount at Safeway supermarkets for qualifying produce items; and a $10 produce prescription from eight participating health systems in the state that can be redeemed at Safeway supermarkets.[969]

Nutrition incentive programs, such as the produce prescriptions programs and the Double Up programs, have demonstrated success in increasing fruit and vegetable consumption,[970] particularly among individuals living in under-resourced communities.[971] Produce prescription programs have been known to improve health outcomes especially among people with diet-related chronic diseases.[972,973] A study in the *Journal of Nutrition Education and Behavior* reported an increase in fruit and vegetable spending in a rural low-income community in Maine with a double-dollar pricing incentive, primarily among customers who were eligible for SNAP.[974]

Over the last decade, nutrition incentive programs have expanded widely across the United States as an evidence-based solution to increasing fruit and vegetable consumption among food insecure individuals.[975] These incentive programs have been reported to reduce food insecurity,[976,977] and increase fruit and vegetable consumption for individuals with diabetes,[978] heart disease,[979] hypertension,[980] and obesity.[981,982] These programs, which increase the purchasing power of fruits and vegetables among SNAP users, have a significant impact in helping low-income individuals, particularly those experiencing food insecurity, manage and treat chronic illness by significantly reducing costs for fruit and vegetables and improving access to nutritious food. Increasing fruit and vegetable consumption has been proven to impact both the prevention and treatment of disease[983] and demonstrates the importance of food as medicine programs and interventions. However, since many of these programs operate in conjunction with SNAP benefits, there are certain populations that are unable to participate in these programs, such as undocumented immigrants who are ineligible for SNAP.[984]

Supporting Access to Food Resources

While nutrition incentive programs have proven to be successful in reducing food insecurity[985,986] and increasing fruit and vegetable consumption among individuals with diabetes,[987] heart disease,[988] hypertension,[989] and obesity,[990,991] research has also suggested that economic hardship is a barrier to maximum program participation and sustainability.[992] In a 2019 study published in the journal *Translational Behavioral Medicine* that focused on a program providing farmers' market vouchers, patients enrolled in the produce prescription program reported the following obstacles to full participation: 1) transportation issues impacted shopping and eating behaviors and limited access to farmers' markets to use fruit and vegetable prescription vouchers; 2) limited and unreliable income affected shopping and eating patterns before, during, and after the program; 3) individual influences such as personal or perceived motivations for program participation impacted program engagement.[993]

Additionally, a 2018 analysis of produce prescription programs published in the *AMA Journal of Ethics* reported that despite reducing financial burdens and increasing access to fruits and vegetables, prescription programs might have unintended psychosocial consequences on low-income participants such as negative feedback loops, coupon stigma, transportation issues, and the limitation of grocery shopping locations.[994] These studies demonstrate that solely improving access to nutritious foods may not be enough, programs need to combine and incorporate other interventions, including nutrition and food education, transportation, cooking materials, and additional resources, including financial support.

Food as medicine programs that develop and implement linkages between clinics and community organizations can increase existing resources and also improve service delivery.[995,996,997] A unique produce prescription program in Cuyahoga County, Ohio, formed a broad collaboration of partners including academics, clinical partners, public health professionals, and a local extension center to design, coordinate, and guide the implementation of the program.[998,999] The program was piloted in 2014 with the goal to increase fruit and vegetable consumption and increase healthy birth outcomes among expectant or new mothers, expanding in 2015 to include individuals with hypertension.[1000] Participants reported visiting at least one farmers' market along with increased communication with healthcare providers related to diet. In addition, these participants exhibited significant changes in dietary behavior, including increased fruit and vegetable consumption and decreased fast food consumption.[1001] This food as medicine program proved to be a successful model for improving fruit and vegetable consumption among food-insecure patients with hypertension by connecting a broad collaboration of partners with farmers' markets to promote the use of community food resources.[1002]

Primary Care Physicians and Food

Despite the evidence connecting food and diet to health, nutrition counseling is not frequently provided by clinicians (including primary care physicians) to their patients.[1003] It has been shown that patients who receive advice from their doctors regarding weight loss are more likely to improve their diet, increase activity, and lose weight.[1004] Therefore, physician-delivered counseling on diet and nutrition may be particularly effective at changing patient behavior and improving their understanding of recommended dietary patterns.[1005,1006] Patient interest in nutrition also reflects a desired trend in health care: a shift from disease management and treatment toward preventive care, in which diet plays a key role.[1007] If nutrition counseling is such an effective tool that healthcare providers could use to improve patient health, then why is it provided so sporadically?

One reason that primary care physicians might be unwilling to provide nutrition and diet counseling to their patients might be a lack of knowledge about how to provide these nutrition interventions. Food interventions can help patients manage their chronic diet-related diseases, such as diabetes, cardiovascular disease, and hypertension, yet training in how to provide these interventions is not required in many medical schools across the country.[1008,1009,1010] Since the 1980s, the National Research Council has recommended that medical school curricula include at least twenty-five hours of nutrition education.[1011] Yet, in a 2012 survey of more than 100 medical schools in the United States appearing in the *Journal of Biomedical Education*, only 2 9 percent of the schools reported providing the recommended 25 hours of nutrition education, and only 18 percent required a dedicated nutrition course in their curriculum.[1012] Furthermore, the Association of American Medical Colleges does not incorporate nutrition among its core competencies for medical students.[1013,1014] Many doctors are therefore left to figure out the symptoms and treatments of diet-related issues without the appropriate training.[1015]

This issue expands outside of the United States as well: A systematic review of nutrition education in medical programs around the world appearing in *The Lancet* concluded that "nutrition is insufficiently incorporated into medical education, regardless of co untry, setting, or year of medical education."[1016] As a result of this minimal training, medical students across the globe lack the "knowledge, skills, and confidence" to successfully incorporate nutrition into their practice,[1017] and very few doctors refer patients to dietitians even when their diagnosis is connected to nutrition.[1018] Thus, many patients, even among those who visit their doctor, do not receive nutrition education[1019] and lack both access to[1020] as well as insurance reimbursement[1021] for additional appointments.

Many medical students recognize the importance of nutrition in health, even if they are not required to take a course about nutrition in medical school. In a 2019 survey of third-year medical students at the Medical University of South Carolina appearing in the *Journal of the American College of Nutrition*, most students responded that talking about nutrition and diet with patients was important.[1022] Forty-three percent of respondents said that they provided nutrition counseling even without any formal education in their school curriculum on the topic.[1023] Further investing in medical school nutrition curricula will instill the knowledge, skills, and confidence necessary for medical professionals to provide more effective treatment through informed diet counseling and nutrition education.[1024] Diet counseling

from physicians will also help patients interpret all of the nutritional information they are likely to find online and on social media, improving their overall nutrition literacy.[1025]

Some physicians and medical schools have begun incorporating "culinary medicine" into their practice.[1026,1027] Culinary medicine is a field that combines nutrition education, individual medical needs, and practical education about food preparation and cooking.[1028,1029] Culinary medicine programs have been proven effective at improving the knowledge and confidence of medical students as they become doctors.[1030,1031,1032] [More information about culinary medicine can be found in Part 3]. However, since not all medical schools incorporate culinary medicine into their curriculums as elaborated above, many patients are still left with little in the way of nutrition education from their primary care providers.[1033]

Furthermore, while many patients will attempt to improve their diets when counseled by a physician,[1034] doctors need to be cautious not to stigmatize their patients and make them feel "fat shamed."[1035] As medical student Triya Chakravorty wrote in the *BMJ*, "[i]n a health care setting, negative attitudes held by healthcare professionals will make patients feel stigmatised and reluctant to access health care services, further damaging their long term health."[1036] To better serve patients of all sizes, healthcare professionals should be trained in techniques to talk about weight with patients without shame or judgment.[1037]

Medical school curricula have been developed historically, focusing on biology, behavior, and disease rather than more inclusive approaches that include nutrition education. Emily M. Broad Leib, the Director of the Food Law and Policy Clinic of the Center for Health Law and Policy Innovation at Harvard University, told *The Counter*, "because [nutrition] wasn't prioritized for so long, there aren't a lot of faculty and medical schools that have any knowledge about nutrition and diet. To build it into schools now requires real investment in hiring and training."[1038] In her analysis of food as medicine in medical programs, Sarah Downer, a clinical instructor at Harvard's Center for Health Law and Policy Innovation, writes:

> Theories for the lack of progress include lack of leadership or faculty level nutrition champions at many medical schools, lack of compelling training opportunities (such as fellowships) focused on nutrition, and rapidly advancing nutrition science coupled with rampant public nutrition misinformation might have minimised the perceived credibility of nutrition science among physicians.[1039]

In a Harvard Law School Food Law and Policy Clinic report, "Doctoring Our Diet: Policy Tools to Include Nutrition in U.S. Medical Training," the authors note that "[t]he lack of comprehensive nutrition education for physicians represents a missed opportunity for doctors to promote good health, illness prevention, and treatment of chronic diseases."[1040]

Additionally, requiring comprehensive nutrition training as a component of healthcare clinician education will ensure equitable patient access to nutrition expertise no matter their geographic location or the type of doctor they are seeing. Ways to ensure the incorporation of nutrition into medical education curricula include legislative mandates, making government funding for schools contingent upon inclusion of nutrition courses; integration of nutrition coursework into accreditation standards; and the inclusion of nutrition questions on board and other qualifying examinations.[1041]
"Doctoring Our Diet: Policy Tools to Include Nutrition in U.S. Medical Training" also includes numerous recommendations for educators at both the undergraduate and graduate levels in order to best improve the quality of nutrition education medical professionals receive, thus improving the quality of nutrition counseling they provide to their patients. Recommendations include:

- Amend the American Council of Graduate Medical Education (ACGME) accreditation requirements to include nutrition education.
- Tie government funds for residency programs to the inclusion of nutrition education.
- Include nutrition in state continuing medical education requirements.
- Include nutrition in continuing education requirements for federally-employed doctors.[1042]

Executing these changes will empower future and practicing physicians to recognize the relationships between food, diet, and health and provide up-to-date evidence-based advice on eating habits, preventive health and disease management, all of which will help optimize health outcomes for patients.

How Marketing and Legalized Health Claims Obfuscate the Impact of Food on Disease

Front-of-package (FOP) food claims and descriptive key words and phrases are frequently used in food marketing and often create confusion among consumers.[1043,1044] These claims influence consumer decision making for both consumers with high nutritional knowledge and health motivation and those without.[1045] Consumers' understanding of these types of claims is relevant to food as medicine because it sheds light on some of the most accessible health and nutrition information consumers receive: marketing. Furthermore, FDA-approved health claims in particular demonstrate what the average consumer is likely to believe about the relationship between diet and disease,[1046] because these claims are so pervasive in everyday life.[1047]

There are three types of claims that can be used by food companies: health claims, nutrient content claims, and structure/function claims.

Health Claims

A health claim is defined by the FDA as having two components: "(1) a substance (whether a food, food component, or dietary ingredient) and (2) a disease or health-related condition."[1048] If a statement does not have these two things, then it is not considered a health claim, and is therefore not subject to premarket review and authorization from the FDA.[1049] There are two different types of health claims: authorized and qualified (see related Spotlights).

Many players in the food industry have attached health claims to their products for decades. In 1886, Coca-Cola was sold as a patented medicine and "brain tonic"; Dr. Pepper was also advertised as a "brain tonic" in drugstores.[1050,1051] As recently as 2013, Coca-Cola released advertisements promoting Coke products as part of a healthy lifestyle working to combat obesity.[1052] Other advertisements from Coca-Cola promised to cure headaches and relieve mental and physical exhaustion.[1053] Kellogg's is another

Spotlight: Qualified Health Claims

Qualified health claims, which are supported by scientific evidence but do not meet the significant scientific agreement standard required for the FDA to approve an authorized claim, are also a frequently used marketing strategy.[1054,1055] In order to ensure that these claims are not false or misleading to consumers, they must be accompanied by disclaimers or additional language to accurately communicate the level of scientific evidence supporting them.[1056] These disclaimers include phrases such as "supportive but not conclusive," "very limited and preliminary scientific research," "scientific evidence suggests but does not prove" or "limited scientific evidence."[1057] Including these phrases that are not accepted by the FDA as an authorized claim can confuse consumers, as they are left not knowing what to believe about how their diet will affect their health.[1058]

An example of a qualified health claim that has been approved by the FDA: "Supportive but not conclusive research shows that eating 1.5 ounces per day of walnuts, as part of a low saturated fat and low cholesterol diet and not resulting in increased caloric intake, may reduce the risk of coronary heart disease."[1059] There are dozens of similar qualified health claims that have been approved by the FDA.[1060] These include statements about tomatoes and cancer,[1061,1062] nuts and coronary heart disease,[1063,1064,1065] psyllium husk and diabetes,[1066] cranberries and urinary tract infections,[1067] and more.

Spotlight: Authorized Health Claims

Also called "significant scientific agreement" health claims, authorized health claims connect specific molecules and nutrients with specific diseases and disease states. They require a rigorous standard of agreement among qualified experts in order to be used.[1068] This "significant scientific agreement" is determined by the FDA, which considers "the totality of the publicly available scientific evidence (including evidence from well-designed studies conducted in a manner that is consistent with generally recognized scientific procedures and principles)."[1069] Since 1990, when the Nutrition Labeling and Education Act was passed and the FDA was made to regulate health claims, 12 health claims have been authorized for use.[1070]

While none of these claims have been revoked by the FDA yet, one claim has been challenged: the claim that soy protein reduces risk of heart disease.[1071] A rule has been proposed to revoke this authorization, as it no longer meets the substantial scientific agreement requirement.[1072] There have been calls for more research into soy protein to have evidence upon which to base a soy protein food health claim.[1073]

Health claims of this type can also be made as an "authoritative statement" of a scientific body.[1074] The scientific bodies that can make these authoritative statements include the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), and the National Academy of Sciences.[1075] There are currently two authorized health claims based on authoritative statements.[1076,1077]

Some examples of a model authorized health claim, according to the Code of Federal Regulations:

- "Adequate calcium throughout life, as part of a well-balanced diet, may reduce the risk of osteoporosis."[1078]
- "Eating a healthful diet low in fat may help reduce the risk of some types of cancers."[1079]
- "Diets low in sodium may reduce the risk of high blood pressure, a disease associated with many factors."[1080]
- "Diets low in saturated fat, cholesterol, and total fat may reduce the risk of heart disease. Heart disease is dependent upon many factors, including diet, a family history of the disease, elevated blood LDL-cholesterol levels, and physical inactivity."[1081]
- "Low fat diets rich in fiber-containing grain products, fruits, and vegetables may reduce the risk of some types of cancer, a disease associated with many factors."[1082]

Note that these types of health claims include the word "may" or "might."[1083]

company with a history of making medicinal claims about its products; in fact, the founder, John Kellogg, MD, started by serving medicinal cereals and granolas to a health institution.[1084,1085] Most recently, through its acquired brand, Insurgent Brands, makers of famed RXBar, it introduced RX Cereal as an attempt to rebrand itself under the "clean" and "healthy" food labels.[1086] The cereals are made with "plant-based protein" using "a mix of pea protein, almonds and brown rice to provide its protein."[1087]

Nutrient Content Claims

Another strategy commonly used by food marketers is nutrient content claims, which tell consumers about certain nutrients that are in the food.[1088] Any claims about the levels of nutrients in food that are not on the nutrition information panel are considered nutrient content claims, and most are regulated by the FDA.[1089,1090,1091]

There are two types of nutrient content claims: express and implied.[1092] Express nutrient content claims are direct statements about the nutrient levels in food.[1093,1094] This includes terms and phrases such as "high in...," "light/lite," and calorie counts, among others.[1095] Implied nutrient content claims, however, only suggest the presence or absence of certain nutrients.[1096] This includes claims such as "high in oat bran" (oat bran is not a nutrient, but the presence of this ingredient suggests the presence of dietary fiber to the consumer) and "contains the same amount of [the nutrient] as [other food]."[1097]

These are particularly powerful at influencing consumers' beliefs about the "healthiness" of foods. In a 2018 study of nutrient content claims on snack foods, researchers found that consumers perceived foods with nutrient content claims to have healthful attributes, and consumers were more likely to purchase those foods.[1098]

Structure/Function Claims

Structure/function claims are statements that describe how a given nutrient or ingredient in the food affects or maintains the structure or function of the human body.[1099] "Calcium builds strong bones" is a prime example of a structure/function claim.[1100] These are perhaps better known for being used on dietary supplements, but are used on conventional foods as well.[1101] Structure/function claims on food must relate to the food's nutritive effects, whereas on dietary supplements they can relate to non-nutritive effects as well.[1102,1103] These claims must be truthful and not misleading; however, they are not subject to premarket approval from the FDA before they are used.[1104]

These types of claims received scrutiny in 2016, particularly the use of them on infant formula packaging.[1105] This led the FDA to issue draft guidance on how marketers can use structure/function claims on infant formula labels in September 2016.[1106] While this guidance does not have the force of law, it was the first time that the FDA shared its thinking about structure/function claims for a food product specifically.[1107,1108] Clearly there is plenty of room for the FDA to better regulate the use of these claims in foods; as researcher John C. Wallingford wrote in *Advances in Nutrition* in 2018, "Consistent standards can ensure that [structure/function] claims across food types are truthful and not misleading, and protect consumers' access to new scientific learnings about the functions of substances in foods."[1109]

Use of Unregulated and Misleading Health-Related Terms

Terms such as "natural" can be found all over products on supermarket shelves. However, these labels are not regulated and consumers are often unaware of what they actually mean.[1110] The FDA has not established a formal definition for the term "natural."[1111,1112,1113] Addressing the term, the FDA wrote:

> The FDA has considered the term "natural" to mean that nothing artificial or synthetic (including all color additives regardless of source) has been included in, or has been added to, a food that would not normally be expected to be in that food. However, this policy was not intended to address food production methods, such as the use of pesticides, nor did it explicitly address food processing or manufacturing methods, such as thermal technologies, pasteurization, or irradiation. The FDA also did not consider whether the term "natural" should describe any nutritional or other health benefit.[1114]

Meanwhile, the USDA defines the term "natural" as products "containing no artificial ingredients or added colors" and "is only minimally processed," meaning it is "processed in a manner that does not fundamentally alter the product."[1115] The lack of guidelines and loose definitions mean that animals raised with hormones and antibiotics can still be labeled "natural," as can Cheetos, lemon-flavored Oreos, and Skippy peanut butter.[1116]

There's ample evidence to demonstrate that big food companies profit from confusion among consumers. A *Consumer Reports* survey found that 73 percent of respondents purchased products labeled "natural"—a greater number than those who purchased foods with the stricter "organic" label.[1117] And

another survey performed by Technomic, a foodservice consulting company, found that one in five consumers are willing to pay more for products labeled "natural" and "organic."[1118]

A study published in the journal *Nutrients* in 2021 found that many consumers feel that food products containing the claim "natural" or the "organic" label are superior to food without these claims or labels, even if the product is a chip or cookie.[1119] These feelings could arise from the manner the food was grown or produced, or the health benefits of food that may not be man-made.[1120] This effect is commonly called a "health halo."[1121,1122,1123] In one 2015 study published in *Psychology & Marketing*, researchers found that the presence of a health halo (in this case, the word "organic") reduced negative consumer perceptions of food products that otherwise had no nutritional information[1124] (note that the USDA has strict requirements for use of the word "organic" on food labels).[1125,1126] Absent any specific information about the nutritional content of foods, perceived health terms on package labeling improves consumers' perceptions of the quality and healthiness of the product.[1127] Given the previously mentioned *Consumer Reports* survey,[1128] it is possible that the unregulated word "natural" might have a similar health halo effect.[1129] In fact, the health halo effect has been found even for products made by companies with reputations as being socially responsible—a characteristic that seemingly has nothing to do with the nutritional quality of the food.[1130]

Using "natural flavors" also has proved to be a lucrative marketing tool for many food manufacturers.[1131,1132] Unlike "natural," however, the FDA does have a definition for the phrase "natural flavor":

> The term natural flavor or natural flavoring means the essential oil, oleoresin, essence or extractive, protein hydrolysate, distillate, or any product of roasting, heating or enzymolysis, which contains the flavoring constituents derived from a spice, fruit or fruit juice, vegetable or vegetable juice, edible yeast, herb, bark, bud, root, leaf or similar plant material, meat, seafood, poultry, eggs, dairy products, or fermentation products thereof, whose significant function in food is flavoring rather than nutritional.[1133]

However, many of these natural flavors undergo intensive chemical processing before they are used, making the distinction between which flavors are "natural" or "artificial" murky and difficult for consumers to understand.[1134,1135] As with artificial flavorings, "natural" flavorings are created in a lab, often with the addition of preservatives and emulsifiers; once a team of professional "flavorists" is done extracting and distilling a natural flavor from a plant or animal, it has the same chemical composition as a synthetic artificial flavor.[1136,1137]

The lack of strict regulation concerning the use of the term "all natural" by the FDA has kept litigation between consumers and food companies prevalent,[1138] as consumers are often left feeling misled.[1139,1140] Lawsuits such as these often have a secondary purpose, which is to put pressure on the FDA to regulate "natural," either by creating guidelines for when the word can be used or by banning use of it altogether.[1141,1142,1143] For example, a 2016 class-action lawsuit against Kind LLC (ie, Kind Bars) accused the brand of using the phrases "all natural" and "non-GMO" despite the snack foods containing genetically-modified and highly processed ingredients.[1144] The lawsuit was put on hold in 2018 pending guidance from the USDA or FDA regarding the definition of "natural," but was allowed to proceed once again in early 2019 due to a lack of movement on the part of the government.[1145] The case was certified in 2021,[1146,1147] but has yet to be decided as of publication.

Dr. Marion Nestle, PhD, Paulette Goddard Professor of Nutrition, Food Studies, and Public Health, Emerita, at New York University, has done extensive research on food labeling practices and the way food marketers use labels to mislead consumers. On her website, Food Politics, Dr. Nestle frequently writes about the efforts made by these marketers to advertise their products as "natural" or "healthy."[1148,1149,1150,1151] While "healthy" does, technically, have a definition according to the FDA, it is a broad definition: the term can be used when food products "(1) Are not low in total fat, but have a fat profile makeup of predominantly mono and polyunsaturated fats; or (2) contain at least ten percent of the Daily Value (DV) per reference amount customarily consumed (RACC) of potassium or vitamin D."[1152] According to Dr. Nestle, "natural" and "healthy" are "about marketing, not health."[1153]

The "natural" label is not the only one to go largely unregulated.[1154] Terms like "lightly sweetened," "made with real...," and "multigrain" also lack official definitions, leaving customers vulnerable to overinterpreting the nutritional value of products carrying these labels.[1155] Additionally, the terms "superfood" and "miracle food" can misinform the public

by implying to consumers that one specific "superfood" is able to provide all the nutrients they need for health,[1156] these are also unregulated terms.[1157] Studies used to back "superfood" claims are often sponsored by the companies and organizations representing the foods they wish to promote.[1158] The term "superfood" influences consumer behaviors and their value judgements when making food choices at the grocery store, as it convinces consumers that certain foods have more value than others.[1159] This marketing tactic does not have to even be directly used by the food company selling the product; media coverage and informal marketing communication usage of the term also influences consumer behavior.[1160] In fact, scientists researching the health benefits of these so-called "superfoods" frequently use the term in their academic publications.[1161,1162]

Another way food marketers imply that a product may improve consumers' health is by drawing attention to recipe changes.[1163] Companies often advertise foods as "reduced sodium" or "reduced calorie" in hopes of attracting diet-conscious customers; however, the "reduced" claim is only a comparison to the product's original formulation.[1164] These claims do not specify the nutrient content of the original item, meaning that a manufacturer could label a food product as "reduced sodium" even if its salt levels far exceed the recommended daily allowance.[1165]

"Healthy" Beverages

The past twenty years have seen a surge in the production and sales of functional beverages that promise health benefits to consumers.[1166] These include beverages such as kombucha, kefir, energy drinks, and vegetable juices.[1167] Food companies capitalize off the perceived health benefits of these drinks in order to target marketing more effectively toward people whose health values have shifted away from sugar-sweetened beverages.[1168] The marketplace is now filled with probiotic drinks, mushroom-infused teas and beers, and beverages containing trendy wellness ingredients such as nootropics and adaptogens.[1169]

One of the most popular types of functional beverages is those which are fermented, such as kombucha and kefir,[1170,1171,1172] many of which have been produced and consumed by cultures around the globe for centuries.[1173,1174] These types of beverages are popular in part due to the presence of pre- and probiotics, which can be beneficial for gut health.[1175] Kombucha in particular has seen immense growth in popularity.[1176] The kombucha market was worth more than $1.5 billion in 2019, and is expected to grow to at least triple that by 2027.[1177,1178] International beverage companies, such as PepsiCo and Coca-Cola, have purchased commercial kombucha companies to capitalize off this consumer interest.[1179,1180]

Sports and energy drinks, designed to help athletes hydrate and recover after physical exertion, are also popular among the non-athlete population, particularly adolescents.[1181,1182] The beneficial attributes of these beverages for athletic performance is well-established, but it is unclear how beneficial they are for people not performing strenuous physical exercise.[1183] Companies producing these drinks can be expected to continue selling them to a larger audience, as the sports drink market is projected to continue growing in the coming years.[1184]

Food Industry-Funded Research

Food industry leaders, including both corporations and agricultural boards, have long provided funding to scholars and organizations researching the nutritional benefits of various foods.[1185,1186,] This funding might, of course, contribute to bias in the results of nutrition studies,[1187,1188] which then can skew dietary guidelines and the foods that consumers choose based on perceived healthfulness.[1189] Furthermore, the money invested into research by these industry players shapes the research agenda and determines which nutritional topics are investigated.[1190] There are many groups funding research, including large corporations (such as Coca-Cola[1191]), trade associations (such as the National Confectioners Association[1192]) and agricultural boards (such as the Hass Avocado Board[1193]).

On her website, Food Politics,[1194] Dr. Marion Nestle has long advised consumers to be skeptical of industry-funded research.[1195,1196,1197,1198,1199] Every week she highlights a recent food study that is either fully or partially funded by a figure or organization with a stake in the food item being researched. For example, Dr. Nestle highlighted the funding of a 2018 study between breakfast consumption and body weight funded by a leading global breakfast cereal company Cereal Partners Worldwide, a partnership with Nestlé and General Mills.[1200] Dr. Nestle wrote of the study's "predictable results," which concluded that regular breakfast consumption (such as a bowl of cereal) was associated with healthier body weight.[1201]

In addition to "Big Food," agricultural boards are frequent funders of food research.[1202,1203] In recent years, the Almond Board of California has funded two studies, one in *Phytotherapy Research* in 2019 and another in *Nutrients* in 2021, assessing the impact of almond consumption on wrinkles.[1204,1205] In both studies, researchers compared before-and-after photographs to analyze changes to wrinkle severity among groups of menopausal women who replaced 20 percent of their daily caloric intake with almonds over a 16 week period.[1206,1207] Despite the small sample size and brief study period, researchers concluded that regular almond consumption may reduce signs of photoaging.[1208,1209] Dr. Nestle featured the articles, and the media coverage surrounding them, on her Food Politics blog in September 2021.[1210]

In 2021, Dr. Nestle wrote about another study funded by an agricultural board: a study from *The Journal of Nutrition* partially funded by the Hass Avocado Board.[1211] The study determined that daily avocado consumption may lead to an improved gut microbiome.[1212] However, Dr. Nestle noted that the positive effects attributed to avocados in this study could apply to other foods.[1213] She writes:

> All fruits and vegetables provide nutritional value, and the best way to get the nutrients you need is by eating a variety of them. If you like avocados, include them in that variety. If not, don't.
>
> The Haas marketers want you to think that avocados are a superfood. Alas, there is no such thing. All fruits and vegetables provide nutritional value. By that criterion, all fruits and vegetables are superfoods.[1214]

"Big Soda" (a term used by many activists to describe the soda industry), notably Coca-Cola, is a known funder of health organizations and nutrition research around the globe.[1215,1216,1217,1218,1219,1220] In 2015, AP reported on leaked emails that revealed Coca-Cola had input in the research and strategy development of the Global Energy Balance Network (GEBN), a nonprofit dedicated to

fighting obesity.[1221,1222,1223] The GEBN's major arguments included claims that consumption of sugar-sweetened beverages is not linked to obesity.[1224] Coca-Cola was also found to have some influence over researchers studying childhood obesity by funding their work,[1225] and from 2011 until 2015, the company attempted to convince the CDC and the World Health Organization to promote exercise (rather than diet) as a solution to obesity.[1226,1227] Coca-Cola is not the only major beverage group to use funding as an attempt to sway research; soda giant PepsiCo and the American Beverage Association, a lobbying group, have also funded studies that did not find a correlation between consumption of sugar-sweetened beverages and obesity.[1228,1229,1230]

More broadly, the sugar industry's funding of nutrition research has a long history; publications from as far back as the 1960s that skewed evidence about the cause of coronary heart disease have had sugar industry funding.[1231,1232] "[I]t was unfortunate that these papers were published because they influenced the public discussion about the health impact of sugar," said Michael Jacobson, PhD, co-founder and former long-term Executive Director of the Center for Science in the Public Interest, in an interview on National Public Radio.[1233]

Gary Sacks, PhD, a fellow at the Global Obesity Centre, Institute for Health Transformation, School of Health and Social Development, and faculty member of Health at Deakin University, in Australia and his colleagues reviewed the 10 most-cited "nutrition and dietetics-related journals" in 2018 for the journal *PLoS ONE*. The researchers found that 13.4 percent of studies on nutrition published in the leading nutrition journals featured involvement from the food industry, either through funding, affiliation, or other connections.[1234] Furthermore, the study revealed that more than 55 percent of research findings from articles with food industry involvement reported food industry-favorable results as compared to articles not backed by the food industry.[1235]

Of note, some question whether peer-reviewed journals should deny publications funded by industry. For example, thirty percent of the studies published in *The Journal of Nutrition* (*JN*) in 2018 had industry funding.[1236] When asked by *Scientific American* about this, *JN*'s editor-in-chief, Teresa Davis, said, "I think it's not appropriate for us to discriminate based on the institution the manuscript is submitted from, or the funding source, or the country."[1237] She also added that, due to lack of financial support from other sources (including the government), researchers often have no other options to fund their work.[1238]

Industry influence over research agendas causes a narrowing of the topics that are studied in peer-reviewed journals.[1239,1240] "The influence on the research agenda might allow the food industry to narrowly frame public health problems and policy solutions as needing technological intervention rather than behavioural or system-wide interventions," wrote researchers Alice Fabbri, Taylor J. Holland, and Lisa A. Bero in an analysis for *Public Health Nutrition* published in 2018.[1241] This influences the kind of information available to the public and to policymakers seeking solutions to public health problems, and corporate interests are not always aligned with the health needs of the people.[1242]

And according to Dr. Sacks and colleagues, writing in *PLoS One* in 2020:

> There are many reasons why food companies might be involved in nutrition-related research. These reasons may include unobjectionable motives such as a willingness to develop new knowledge, assist in research translation and contribute expertise and resources.[1243] However, from a public health perspective, several concerns have been identified regarding food industry involvement in research. These include: 1) the creation of increased marketing opportunities for industry products, many of which are harmful to population health;[1244] 2) the establishment and nurturing of relationships between the food industry and nutrition researchers that serves to increase perceived industry credibility, reduce industry criticism, and encourage increased dependency on the food industry;[1245,1246] 3) industry influence over research agendas to preferentially focus on topics likely to benefit industry interests, rather than topics of public health importance;[1247] 4) industry influence on the methods, conclusions and impact of research in ways that are likely to favour industry interests over and above other factors;[1248,1249,1250,1251] and 5) use of research for political purposes.[1252,1253] An increased dependence on food industry funding by academics has been documented,[1254,1255,1256,1257] with food industry funding sometimes acknowledged as a strategically important funding source for the university sector.[1258,1259]

Part III

Food as Medicine: Interventions, Programs, Policies and Practices

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The global epidemic of diet-related diseases has led to the increased use of food as medicine as a way to treat these illnesses and avoid costly healthcare.[1260,1261] Food as medicine, however, is not a specific treatment; rather, there are a variety of different food interventions that have been used to help prevent, treat, or co-treat disease.[1262] Some of the most widespread forms of food interventions include medically tailored meals (meals specially designed and prepared for people based on their medical conditions) and food prescriptions (foods assigned by a doctor or health care professional for treatment, co-treatment, or prevention of a disease). Incorporating these solutions directly into programs such as Medicare and Medicaid has proven to be an affordable and effective solution, improving health outcomes and reducing healthcare costs.[1263,1264,1265,1266,1267,1268,1269,1270] A 2019 microsimulation of Medicare and Medicaid food interventions, conducted by researchers from Tufts University and published in *PLoS ONE*, found th at "[e]conomic incentives for healthier foods through Medicare and Medicaid could generate substantial health gains and be highly cost-effective."[1271] The microsimulation determined that offering subsidies for fruits, vegetables, and other select "healthful foods," could save $100 billion in healthcare costs over the lifetime (average lifetime of a Medicare or Medicaid user is 18.3 years) of all Medicare and Medicaid participants from 2009-2014 (82 million adults).[1272] The following section provides an overview of key types of food as medicine interventions, programs, and practices, while spotlighting examples of programs and policies in action.

Food as Medicine Interventions

Medically Tailored Meals (MTMs)

Many people living with chronic disease seek dietary changes to help them manage their health,[1273,1274,1275] but often these patients face a variety of barriers such as cost, food insecurity, lack of food proximity, physical disability, and a lack of educational resources about food as treatment or co-treatment.[1276,1277] Medically tailored meals (MTMs) are a food as medicine intervention that can help overcome some of these barriers, including cost and mobility, through directly providing meals to people living with chronic conditions.[1278,1279] Patients in medically tailored meal programs are provided with meals (oftentimes through delivery) that are individually tailored to their health conditions, medications, and other dietary needs.[1280]

There has been extensive research published about the health effects of MTM programs.[1281,1282,1283,1284] In 2018, Boston-based MTM provider Community Servings supported a clinical trial appearing in the *Journal of General Internal Medicine* of 44 food insecure adults living with type 2 diabetes, providing participants with home-delivered MTMs for 12 weeks.[1285] In this trial, participants reported lower rates of food insecurity and improved Healthy Eating Index scores while receiving meals.[1286] In a 2016 randomized controlled trial appearing in the *Journal of Clinical Oncology* evaluating the impact of home-delivered MTMs provided by the New York City-based God's Love We Deliver to 180 patients with cancer, participants self-reported higher Quality of Life scores after 12 weeks in the program.[1287] Furthermore, in a 2018 study published in *Health Affairs* of diabetes patients experiencing food insecurity, researc hers found that emergency room visits were less frequent among those participating in a MTM delivery program compared to patients participating in a non-tailored meal delivery program.[1288]

Other studies have found connections between participation in MTM programs and reduced health care costs.[1289] MANNA, an organization that provides MTMs to people at nutritional risk as a result of managing serious illness in Pennsylvania and New Jersey,[1290] conducted a 2013 study published in the *Journal of Primary Care & Community Health* of the relationship between its MTM program and healthcare costs. [1291] The researchers found that healthcare costs for each participant were reduced by an average of $10,754 per month in the first three months of receiving services from MANNA.[1292] In another study conducted by Community Servings and published in *JAMA Internal Medicine* in 2019, MTM recipients saw a 16 percent decrease in healthcare costs and fewer inpatient or skilled nursing facility admissions compared to the control group, who did not receive meals from Community Servings.[1293]

MTMs are provided to patients from a variety of sources, including through the work of nonprofits such as God's Love We Deliver, in New York City,[1294] Community Servings, in Boston,[1295] and Project Open Hand, in San Francisco.[1296] Furthermore, numerous public and private health insurers (such as New York's Amida Care,[1297] North Carolina Medicaid,[1298] and California's Medi-Cal[1299]) now offer coverage for MTMs. There is mounting evidence that dietary interventions such as MTMs improve patient health outcomes,[1300,1301,1302,1303] reducing the need for expensive treatments and thus reducing costs for both patients and health insurance companies.[1304]

For uninsured individuals or those whose insurance does not cover MTM programs, some MTM providers provide meals free of charge, such as Community Servings[1305] and God's Love We Deliver.[1306]

Studies have shown MTMs to have a particularly beneficial impact on patients experiencing poverty and food insecurity.[1307,1308] David Waters, CEO of Community Servings, said of clients in an interview with Tom Lee for the journal *NEJM Catalyst*: "They are hungry, they are poor, and, most importantly, they're very isolated by their illness—unable to walk to the store, carry a bag of groceries, or stand at the stove."[1309] According to a 2018 clinical trial published in the *Journal of General Internal Medicine*, "A healthy diet is the cornerstone of diabetes management, but food insecurity incents the consumption of inexpensive, calorie-dense food of little nutritional value."[1310] All of the participants included in the study were experiencing food insecurity; by the end of the trial, 62% of participants reported experiencing food insecurity when not receiving MTMs, whereas only 42% reporting experiencing food insecurity while receiving MTMs.[1311]

Another study appearing in the *Journal of Urban Health* that provided MTMs to individuals with diabetes or HIV in the San Francisco found that the intervention reduced very low food security from 60 percent to 12 pe rcent among participants.[1312] Participants in the study were given healthy meals and snacks designed to provide 100 percent of their daily nutritional needs and energy requirements. After 6 months, MTM recipients ate less fat and sugar and more fruits and vegetables, they binge-drank less, and felt less distressed and more in control of their diabetes.

It is important to note, however, that much of the research regarding MTMs is funded by the organizations providing these services, such as Community Servings,[1313,1314,1315,1316,1317] Project Open Hand in San Francisco,[1318,1319] and Project Angel Heart in Denver.[1320]

While the financial support of these organizations, might result in sponsorship bias in the research findings,[1321] the importance of these studies is not to be underestimated. Further research is needed to reinforce the outcomes and findings already published. Additional studies supported by the National Institutes of Health (NIH), health insurance organizations, policy organizations, and third-party research departments—whether academic or clinical—are crucial to future understanding of the impact and thus widespread implementation of MTMs.[1322] The work and research done by community based organizations (i.e. medically tailored meal programs) have laid the groundwork for demonstrating the positive impact of treating and preventing chronic disease states with meals. In a 2021 food as medicine panel hosted by the University of Pennsylvania's Leonard Davis Institute of Health Economics, panelist Sarah Downer, JD, Associate Director of Harvard Law School's Center for Health Law and Policy Innovation, said, "We need the NIH to really get in the game with funding research on this... and the government is best positioned to do the kind of big investment in preventive long-term studies that we would like to see."[1323]

Fruit and Vegetable Prescription Programs

Produce prescription programs are healthcare interventions wherein doctors or other health care providers (e.g. registered dietitians, pharmacists) "prescribe" certain foods (mostly fruits and vegetables) to help targeted patient populations prevent or manage chronic disease, much like they might prescribe a pharmaceutical drug.[1324,1325] Produce

prescription programs go by a variety of names and are also known as “Pharmacy to Farm,” “Food Prescriptions,” “Fresh Rx,” “ProduceRx,” “Fresh Food Farmacy,” “ Farmacy,” “Fruit and Vegetable Prescription Programs,” “Harvest RX,” ”Veggies as Medicine,” “SuperSNAP,” or “VeggieRx.”

According to the National Produce Prescription Collaborative, a produce prescription program is defined as “A medical treatment or preventative service for patients who are eligible due to diet-related health risk or condition, food insecurity or other documented challenges in access to nutritious foods, and are referred by a healthcare provider or health insurance plan. These prescriptions are fulfilled through food retail and enable patients to access healthy produce with no added fats, sugars, or salt, at low or no cost to the patient.”[1326]

Produce prescription programs provide a financial incentive (e.g. discount, bonus, or credit) to increase access to and consumption of fresh fruits in vegetables among targeted patient populations, which in turn may have an impact on diet-related health outcomes.[1327] Research has demonstrated that produce prescription programs may also be an effective healthcare intervention to reduce food insecurity among patients.[1328,1329,1330,1331] In a 2021 study published in the *Archives of Public Health*, the authors highlight the important impact produce prescription interventions can have on food insecurity and health: “Food insecurity is associated with poor nutritional health outcomes. Prescribing fresh fruits and vegetables in healthcare settings may be an opportunity to link patients with community support to promote healthy diets and improve food security.”[1332]

Federal support for nutrition incentive programs was introduced in the 2014 Farm Bill which authorized the Food Insecurity Nutrition Incentive (FINI) program. This program provided $100 million to fund programs that provided incentives to increase the purchase of fruits and vegetables by low-income consumers.[1333] In the 2018 Farm Bill, FINI was expanded and renamed the Gus Schumacher Nutrition Incentive Program (GusNIP),[1334] after Gus Schumacher, a longtime advocate for healthy food access for low-income households.[1335] The 2018 expansion explicitly earmarks funding and evaluation support for produce prescription programs.[1336] The 2018 Farm Bill authorized up to $25 million in funding over five years for produce prescription programs.[1337]

In 2019, Wholesome Wave, a nonprofit organization, founded by Gus Schumacher and Chef Michel Nischan, that is often credited with pioneering one of the first produce prescription program,[1338,1339] created the National Produce Prescription Collaborative. The goal of the Collaborative is to catalyze the vital role of food and nutrition in improving health and wellness by collectively leveraging the unique opportunities for produce prescriptions to achieve wellness through the healthcare system, and embedding & institutionalizing Produce Prescriptions within the healthcare payment model.[1340]

Produce prescription programs have rapidly expanded across the United States over the past decade. In 2020, Wholesome Wave commissioned consulting firm DAISA Enterprises to conduct a field scan report of produce prescription programs in the United States between 2010 and 2020.[1341] The report identified a total of 108 produce prescription programs across 38 states with nearly a quarter of all identified programs launched in 2019 alone.

Key components of produce prescription programs are discussed below and include:
i) the identification of targeted patient populations by health care providers,
ii) the issuance of a “prescription” or referral for fruits and vegetables,

and ii) the redemption of produce prescriptions at food retail or other settings

Identifying Targeted Patient Populations

Produce prescription programs are distinct in that they partner with health care providers or insurers to identify targeted patient populations who would benefit from increased access to and consumption of fruits and vegetables.[1342] Produce prescriptions are fulfilled through food retail and enable patients to access produce with no added fats, sugars, or salt, at low or no cost to the patient.[1343] According to the National Produce Prescription Collaborative, "when appropriately dosed, produce prescription programs are designed to improve healthcare outcomes, optimize medical spending, and increase patient engagement and satisfaction."[1344]

Health care providers who prescribe produce prescriptions can include physicians, nurses, pharmacists, registered dietitians, social workers, community health workers, and midwives.[1345] Patient eligibility for produce prescription programs is often based on the presence or risk of a diet-related health condition (such as hypertension, diabetes and obesity) and/or socioeconomic criteria such as food insecurity, insurance status and/or income.[1346] A detailed report of current produce prescription programs in the United States commissioned by Wholesome Wave found that 82 percent of programs use diet-related chronic disease as part of eligibility criteria, with 31 percent specifically focused on diabetes.[1347]

Examples of Produce Prescription Programs Targeting Patients With Diet-Related Chronic Diseases

In 2020, Crossover Health Services in North Tulsa, Oklahoma, an under-resourced neighborhood lacking in places to buy fresh food, raised $180,000 to create Tulsa FreshRx.[1348] The program is designed for patients with type 2 diabetes and provides participants with fresh fruits and vegetables every two weeks for one year in addition to lifestyle, nutrition, and cooking classes. The program aims to reduce diabete patients A1C levels (also known as the hemoglobin A1C or HbA1c test—is a simple blood test that measures your average blood sugar levels over the past 3 months[1349]) by 1 to 2 percent over the course of a year which would equate to $16,000 to $24,000 in healthcare cost savings per person per year.[1350]

Another program in Syracuse New York aims to mitigate chronic diabetes among patients who experience food insecurity. St. Joseph's Health Food Pharmacy offers type 2 diabetics enough fresh and healthy food for 2 meals a day, 5 times a week, for the patient and members of the household in addition to nutrition counseling and diabetes management group sessions.[1351] In order to participate in the program participants must have a diagnosis of diabetes with an A1C of 7.5 or higher and screen positive for food insecurity.[1352] "Food insecurity is a predictor of health and is linked to many chronic diseases," explained St. Joseph's Food Farmacy coordinator Deb Mendzef. "We are proud that we will be able to ensure that these patients, and their family members, have the resources necessary to provide a quality and healthy diet."[1353]
The Ohio-based produce prescription program, Health Improvement Partnership-Cuyahoga, is a community healthcare partnership that provides low-income patients managing hypertension with $40 in monthly farmers' market produce vouchers and nutrition counseling at clinical visits.[1354,1355] In a 2018 study on the impact of this program, published in *Preventing Chronic Disease*, participants reported an increase in fruit and vegetable consumption, a decrease in fast food consumption, and improved communication with their health care providers about diet.[1356]

Examples of Produce Prescription Programs Utilizing Various Eligibility Criteria

While the majority of produce prescription programs target patients with diet-related conditions, the program model may have utility for reaching broader populations of low-income patients.[1357] A review published in the *AMA Journal of Ethics* explored the policy implications of produce prescription programs and noted that "Produce Rx programs that seek to enroll participants with low socioeconomic status (SES) could make greater use of existing public assistance systems through which incentives could be disbursed, such as Supplemental Nutrition Assistance Program (SNAP) and Medicaid, thereby enlarging public data on the complex intersections between healthcare, food access, and income." [1358] The expansion of produce prescription eligibility requirements may play an important role in addressing broader social determinants of health that contribute to poor health outcomes in patients.[1359] Below are examples of produce prescription programs that utilize broader eligibility criteria in order to identify low-income populations who may benefit from increased access to and consumption of fruits and vegetables.

Operation Food Search, a hunger relief organization in St. Louis, Missouri, operates a program called Fresh RX: Nourishing Healthy Starts, that aims to enhance birth outcomes for food-insecure mothers and their infants. Fresh RX partners with Missouri Medicaid Health Plans to identify pregnant women who are experiencing food insecurity and provides them with weekly produce shares from a Combined Supported Agriculture Program (CSA) in addition to cooking classes, nutrition resources and supportive services during pregnancy.[1360] A 24 month pilot study with 75 babies delivered in the St. Louis region found that a mother's participation in the program improved food security by 44 percent and reduced the likelihood that her child would be born underweight from 16.3 percent to 11.0 percent, resulting in a savings of $189,000 in healthcare costs during the pilot.[1361] The program estimates that if results similar to the pilot could be achieved for all mothers in the St. Louis's Medicaid system, an additional 118 babies would be born at a healthy weight and Missouri Medicaid would save approximately $5.3 million annually .[1362,1363] Trina Ragain, Director of Policy and Innovation at Operation Food Search noted that "Those savings come from what we know of what it costs when a low birth weight baby is born…they end up in neonatal intensive care, which is expensive."[1364] In 2021, the program launched a three year randomized controlled trial with 750 women to formally evaluate the economic return on treating food insecurity among pregnant women.[1365]

Other produce prescription programs have focused on reaching SNAP participants, as research suggests that SNAP benefits fall short of what households need to afford a healthy diet.[1366] Reinvestment Partners in North Carolina manages a statewide produce prescription program called SuperSNAP where SNAP recipients are identified by health care providers and receive $40 per month to spend on fresh fruits and vegetables at over 500 Food Lion store locations across the state.[1367] A 2021 study published in *JAMA Network Open* found that participation in the SuperSNAP program was associated with a significant increase in the purchase of fruits and vegetables of $31.84 per month and a decrease in the monthly spending on sugar sweetened beverages.[1368]

The Washington State FVRx program partners with public and private healthcare systems to provide SNAP recipients with $10 grocery store vouchers that can be redeemed for fresh, canned, or frozen fruit or vegetables at over 169 participating supermarkets across the state.[1369] This statewide initiative strategically chose to implement the produce

prescription program in counties where the prevalence of low fruit and vegetable intake and food insecurity are disproportionately high. This approach allowed them to target the produce prescription program in counties of greatest need.[1373]

Another produce prescription program called Fresh Rx Farm to Hospital, operating in South Florida, focuses on identifying patients who receive Medicaid or Medicare and patients who pay out of pocket.[1374] Through Fresh Rx Farm to Hospital, oncology, cardiology, stroke and pediatric patients are provided with a free 16-week produce box subscription if they are on Medicare, Medicaid, or pay out-of-pocket for medical expenses.[1375] During the initial weeks of the COVID-19 pandemic, FreshRx launched Farm to Family, an initiative that provided weekly produce and personal protective equipment to first responders and families in need.[1376]

Issuing Produce Prescriptions

Once eligible patients are identified by a health care provider, they are provided with a "prescription" or referral that can be fulfilled through food retail and enables them to access free or discounted produce.[1377,1378] The mechanism for distributing funds to purchase produce in retail settings can include paper vouchers, scannable coupons, loyalty cards, funds loaded onto electronic cards, and phone applications.[1379]

A report of produce prescription programs in the United States commissioned by Wholesome Wave found that the majority (67 percent) of programs issued funds for produce prescriptions in the form of vouchers or coupons.[1380] In a series of more than 60 interviews conducted by The Center for Health Law and Policy Innovation at Harvard Law School, interviewees (including produce prescription program participants, retailers, and coordinators) reported that the advantages of paper vouchers included ease of use across settings, minimal technology requirements and low costs. A limitation of paper vouchers reported by participants is that they may carry stigma or evoke self-consciousness that can impact participation.[1370]

Some produce prescription programs are working directly with food retailers to leverage existing loyalty card programs to distribute monetary funds to participants to purchase produce, eliminating the need for vouchers. For example, Reinvestment Partners manages a statewide produce prescription program in North Carolina and partners with healthcare centers and over 500 Food Lion stores to provide SNAP recipients with $40 per month loaded onto the store's MVP loyalty card for the purchase of fruits and vegetables.[1371] Here is how the SuperSNAP program works[1372]:

- Step 1: The patient must enroll in the program at a participating healthcare center and provide their health care provider with their name, phone number and Food Lion MVP customer loyalty card number. If the patient does not have a Food Lion MVP customer loyalty card, their health care provider can help them sign up for one.
- Step 2: In order to load $40 onto their Food Lion MVP card, the patient must make a purchase of any amount using both their MVP loyalty card and their EBT card at a participating Food Lion location.
- Step 3: The patient can then use their MVP card to access the $40 to purchase fresh fruits and vegetables at any participating Food Lion location.

Other programs are further leveraging technology to streamline the produce prescription process. Wholesome Wave has partnered with Tangelo to pilot an application in California that allows patients to access their produce prescription digitally using their phone

number.[1387] Through this program, funds for produce prescriptions are loaded to the Tangelo app as a restricted wallet that can only be used to purchase fruits and vegetables.[1388] HealthEBucksRX is another technology application that has been piloted at community health centers and allows healthcare providers to create digital vouchers that can be distributed by email, text, or hardcopy to patients and redeemed directly with food retailers by scanning the barcode.[1389] Electronic reporting with HealthEBucksRx allows providers to track patient compliance and sponsors to reimburse retailers.

Partners in Produce Prescription Programs

Partnerships are critical to the successful implementation of produce prescription programs.[1390,1391] A wide variety of partners have been used to redeem prescriptions for fruits and vegetables including farmers' markets, grocery and retail stores, mobile markets, farm stands, food pantries, as well as on-site distribution where the prescription was administered.[1392] A national report commissioned by Wholesome Wave found that 48 percent of programs utilized farmers' markets and 29 percent utilized grocery retail locations to redeem produce prescriptions, while 20 percent of programs reported on-site produce distribution where participants receive their prescribed amount of produce directly at their healthcare institution.[1393]

The most common type of redemption partner used in produce prescription programs is farmers' markets.[1394,1395] Pharmacy to Farm is a produce prescription program administered by the New York City Department of Health and Mental Hygiene that partners with GrowNYC, a farmers' market operator, and local pharmacies to provide patients with fresh fruits and vegetables.[1396] Through this program, pharmacists provide monthly produce prescriptions to patients filling a pharmaceutical prescription to treat high blood pressure and who are also enrolled in SNAP. The produce prescription can be redeemed for $30 worth of fresh fruits and vegetables at more than fifteen farmers' market locations operated by GrowNYC. Cross-sector collaboration between healthcare institutions and farmers' markets can benefit both patients and local farmers. Marcel Van Ooyen, President and CEO of GrowNYC, stated "This initiative has successfully introduced community members to their neighborhood farmers' market, connecting them to this important resource for fresh food and simple, healthy recipes. We want to see small family farms thrive, and all residents, regardless of income, have affordable access to the foods they need to be healthy."[1381]

Collaboration between health care providers and community food retailers may also serve to increase patient awareness of local food resources available to support healthy diets. In addition to providing farmers' market vouchers, The Food Rx program in Chicago also provided diabetic patients with coupons to Walgreens to increase awareness about the recent expansion of fresh produce available at this retailer.[1382] A 2019 qualitative study published in the *Journal of General Internal Medicine* found that a produce prescription program in Cleveland Ohio increased participant awareness of farmers' markets that operate in the community as well as how to use local produce.[1383]

A growing number of hospitals have also implemented produce prescription programs that integrate both the referral and redemption processes on-site at a location within the healthcare system, eliminating the need for participants to visit a community partner to redeem their prescriptions. This approach can potentially address challenges such as transportation and limited food retail hours that may limit participation in community-based redemption models.[1384,1385,1386]

Boston Medical Center was the first hospital system to launch a therapeutic food pantry in 2001 to address the nutritional needs of low-income patients with a variety of chronic health conditions including cancer, HIV/AIDS, hypertension, diabetes, obesity and heart disease.[1397] Through this program, patients are identified by primary care providers who write and issue produce prescriptions that are then redeemed at the on-site Preventative Food Pantry for perishable food items such as fruits, vegetables and meats. The on-site food pantry is open five days a week and patients can redeem their prescriptions up to two times per month.[1398]

In 2018, the Children's Hospital of Pennsylvania launched the first pediatric, hospital-based Food Pharmacy program to promote nutrition and address food insecurity among families in primary care and specialty care sites.[1399] Through this program patients are screened for food insecurity at clinical visits and referred to the on-site Food Pharmacy where they receive a three-day supply of nutritious food for the household. Food insecure families are able to access the Food Pharmacy at follow up clinical visits.[1400]

Geisinger, a regional health care provider that serves parts of Pennsylvania and New Jersey,[1401] began an initiative called Fresh Food Farmacy in 2016.[1402] The program serves patients diagnosed with type 2 diabetes who have experienced food insecurity in the past year.[1403] Enrollees in the program receive a prescription of diabetes-appropriate food, and are then able to pick up the ingredients needed on-site to cook ten nutritious meals each week.[1404] In addition, patients receive more than 20 hours of diabetes education and access to free nutrition and wellness classes.[1405,1406] Early stages of data collection for the program have shown that providing food to diabetic patients is much less expensive than providing them with medical care.[1407] According to an editorial published in the *American Journal of Health Promotion* in 2019, the program reported "seeing a 20 percent higher care gap compliance rate for those enrolled in the program. We have also seen a 2-full point reduction in HbA1c among program participants."[1408]

Outcomes and Opportunities

Produce prescription programs represent a promising healthcare intervention to improve food security among targeted patient populations.[1409] Research has demonstrated that produce prescription programs can improve fruit and vegetable consumption,[1410,1411,1412,1413,1414] nutrition knowledge,[1415,1416,1417,1418] and food purchasing practices[1419,1420] among a variety of patient populations. The benefits of produce prescription programs are multifaceted as they can reduce barriers to dietary changes by improving affordability and accessibility of fruits and vegetables and increasing knowledge related to diet-related health conditions.[1421,1422,1423,1424].

While produce prescription programs have been shown to improve the consumption of fruits and vegetables among targeted patient populations, evidence of the effectiveness of these programs on health outcomes are less clear.[1425,1426,1427] Findings from a systematic scoping review published in the *American Journal of Health Promotion* in 2021 reviewed 23 studies published on produce prescription programs and concluded that "studies incorporating health metrics reported mixed effectiveness, with little consensus on the impacts of food prescriptions on blood pressure, BMI, or glucose homeostasis."[1428] Authors attribute inconsistent findings to poor study designs and limited time frames in a nascent body of funded programs.[1429]

Produce prescription programs represent a burgeoning field in the Food as Medicine landscape and will require more rigorous research in order to demonstrate their impact

on longitudinal health outcomes and support their integration into national policy.[1437] In 2022, The Aspen Institute recently released the Food is Medicine Research Action Plan which provides the following recommendations for future research designs of Food as Medicine interventions:[1438]

- Research should be appropriately powered to meaningfully evaluate primary outcomes
- Researchers should prioritize rigorous research designs with a combination of quantitative and qualitative approaches
- Research should always report process and engagement metrics
- Researchers should carefully consider whether the intensity and duration of the intervention is likely to influence outcomes of interest
- Metrics for specific health conditions should be developed in collaboration with primary care and specialist conditions

Produce prescription programs may also have the potential to promote health equity in communities underserved by supermarkets and healthy food retailers. Produce Rx, a produce prescription program run by the Washington DC-based nonprofit DC Greens, helps residents of Ward 8, one of D.C.'s predominantly Black neighborhoods, afford fresh fruits and vegetables from the neighborhood's only full-service grocery store.[1439] In April 2021, Wholesome Wave's CEO, Benjamin Perkins, MA, MDiv, participated in a panel about promoting health equity through food as medicine hosted by the University of Pennsylvania's Leonard Davis Institute of Health Economics.[1440] Regarding the operation of a successful food prescription program, Perkins said: "It's about listening to that community and using their input to inform the way programs are designed and operated. And it's not just about giving them any kind of food, but rather providing them with food that is as meaningful and culturally appropriate as it is nutritious."[1430]

Culinary Medicine

Food science, nutrition, and cooking come together in the science of culinary medicine, which aims to improve patients' conditions by analyzing how food can play a role in preventing or treating a particular disease. According to John La Puma, MD, the Clinical Director and Founder of Chef Clinic, "culinary medicine is a new evidence-based field in medicine that blends the art of food and cooking with the science of medicine."[1431] Culinary medicine takes into account an individual's conditions and dietary needs when designing home-cooked meals and meal plans.[1432] As physician Irl B. Hirsch (et al.) wrote in *Clinical Therapeutics* in 2019:

> Specifically, culinary medicine adds to existing nutrition interventions by integrating the concept of "food pleasure" (ie, both the sensory-based experience of food in terms of taste, smell, texture, and appearance, and the emotions surrounding food) with the scientific knowledge of how food and dietary choices may influence human metabolism, immunity, and pathophysiology.[1433]

It is important to note that culinary medicine is not focused on prescribing specific foods to patients, nor does it attempt to replace prescription medications.[1434] In fact, culinary medicine can be used in conjunction with prescription medications and other nutritional and dietary interventions.[1435,1436] Dr. La Puma wrote of culinary medicine in the journal *Population Health Management*:

> Culinary medicine is not nutrition, dietetics, or preventive, integrative, or internal medicine, nor is it the culinary arts or food science... Culinary medicine is aimed at helping people reach good personal medical decisions about

accessing and eating high-quality meals that help prevent and treat disease and restore well-being.[1441]

Culinary Medicine in Medical School

Culinary medicine, as an emerging field that incorporates the principles of food as medicine, has started to gain traction among physicians and medical schools.[1442,1443] In the United States, United Kingdom, and Spain, "culinary medicine" movements are blending clinical medicine with individual nutrition education that is focused on the practical aspects of food preparation and cooking.[1444] These programs support a health care professional's willingness and ability to recognize nutrition needs and provide appropriate and practical advice to patients.[1445] The first medical school to offer a cooking and nutrition elective in the United States was the State University of New York - Upstate Medical University, in Syracuse, in 2003.[1446]

One of the most prolific culinary medicine projects is the Health Meets Food culinary medicine curriculum, which was developed by Timothy S. Harlan, MD, FACP, a world renowned doctor, chef, teacher and author, while at Tulane University. Dr. Harlan who spent his pre-medical career working in, and eventually owning a restaurant, is also known as Dr. Gourmet.[1447] Currently, the Health Meets Food culinary curriculum consists of more than 30 content-specific modules designed for health care professionals. "Each of the educational modules presents basic and clinical science related to evidence-based nutritional and dietary goals for specific topics, case presentations, recipes, cooking instructions, discussion questions, and quizzes."[1448] The Health Meets Food culinary curriculum is used by medical students, residents, and clinicians at more than 55 academic medical centers across the world. Currently, Dr. Harlan is at the George Washington University School of Medicine and Health Sciences assisting with its culinary medicine programming.

Dr. Harlan is also a senior advisor and former executive director of The Goldring Center for Culinary Medicine at Tulane University's School of Medicine in New Orleans, Louisiana.[1449] Founded in 2012, The Goldring Center is the nation's first culinary medicine center at a medical school. The teaching kitchen provides hands-on training for medical students and residents through elective culinary medicine classes and mandatory interdisciplinary seminars. The Goldring Center also provides Community Classes to the local community interested in learning about nutrition.[1450]

Some culinary medicine programs have a dual focus: to teach participating medical students how to better manage their own health as well as that of their patients.[1451] The courses emphasize cooking with fresh fruits and vegetables and teach participants how to select, store, prepare, and even grow their own produce in order to maximize its nutritional value.[1452] Dr. Jaclyn Albin, the Associate Program Director for the University of Texas Southwestern's Internal Medicine and Pediatrics Residency program, has pioneered culinary medicine courses for her students.[1453] She hopes that culinary medicine will foster lifestyle changes that place students in a better position to manage their health, deal with stress, and reap the benefits of any other medical care they are undergoing, including therapy and dietary consultation.[1454]

The inclusion of culinary medicine within medical training has shown evidence-based efficacy in improving the nutrition knowledge and confidence of medical students as they graduate and become board-certified physicians.[1455,1456] One study published in *Advances in Preventive Medicine* compared medical students who participated in a cooking and nutrition elective in a medical school-

based teaching kitchen versus traditional clinical education. The cooking and nutrition elective resulted in a 72 percent increase in the reporting of total proficiency in providing nutrition counseling to patients.[1466] According to a survey of medical students published in the *American Journal of Lifestyle Medicine*, during the 2019-2020 academic year, a 3-hour culinary medicine training was found to have positive effects on the students' "nutrition knowledge, skills, and attitudes and confidence in patient nutrition counseling."[1467]

Various schools and organizations provide continuing medical education (CME) to physicians and other health care providers about nutrition and food as medicine:[1468]
The American College of Preventive Medicine now offers an Introduction to Culinary Medicine course focusing on "provider education that seeks to incorporate self-care while counseling and empowering patients to make and sustain healthier food choices through shopping and meal preparation," and provides continuing medical education credits and maintenance of certification credits.[1469,1470]
The American College of Lifestyle Medicine offers an online CME program called Lifestyle Medicine Core Competencies, which includes nutrition education alongside other lifestyle practices such as sleep health, weight management, and alcohol use.[1471] The CME's are offered through a collaboration with Rush University Medical Center, American College of Preventive Medicine and the American College of Lifestyle Medicine.
The Health meets Food Culinary Medicine Program offers a Certified Culinary Medicine Specialist program for clinicians to learn how to "[e]xplore the implications of diet on overall health; Enhance the quality of patient counseling; [and] Improve the management of diet-related chronic diseases."[1472] This is a hybrid program, with some virtual (both live and asynchronous) and some in-person components.[1473]

Culinary Nutrition

Culinary nutrition is a term used to describe the practice of incorporating nutrition and food science knowledge into individual preparation of food,[1457] resulting in "an interdisciplinary approach to food, ranging from nutrition and dietetics to culinary arts and gastronomic sciences," wrote researchers in the *International Journal of Gastronomy and Food Science* in 2021.[1458] This interdisciplinary approach is proving effective; culinary nutrition education programs are gaining traction as motivators for behavior change in patients managing chronic disease.[1459] According to a 2020 article in *Health Promotion Practice*, "Evidence of the benefits of culinary nutrition education is growing in the literature. Culinary nutrition education programs are naturally experiential, social, skills-based, and effective in improving nutrition-related beliefs, knowledge, and behaviors."[1460] While the term "culinary nutrition" is often used interchangeably with culinary medicine, the latter is primarily associated with educating physicians and health care workers as well as physician extenders.[1461,1462] Jacqueline B. Marcus, MS, RDN, author of *Culinary Nutrition: The Science and Practice of Healthy Cooking*, writes, "People have integrated nutrition, food science and cooking since the beginning of time—without even knowing it."

Dietary Supplements, Nutraceuticals and Functional Foods

Dietary supplements, nutraceuticals (sometimes called "bioceuticals"), and functional foods are foods, or supplements to food, that are ingested with the intention of providing a physiological or medicinal effect.[1463,1464,1465]

Dietary Supplements

The National Institutes of Health Office of Dietary Supplements (NIH ODS) defines a dietary supplement as "[a] product (other than tobacco) that is intended to supplement the diet; contains one or more dietary ingredients (including vitamins, minerals, herbs or other botanicals, amino acids, and other substances) or their components; is intended to be taken by mouth as a pill, capsule, tablet, or liquid; and is identified on the front label of the product as being a dietary supplement."[1474] Products of this type are not called "dietary supplements" in every jurisdiction; for example, the United Kingdom's Food Standards Agency calls them "food supplements," defined as "any food the purpose of which is to supplement the normal diet and which is a concentrated source of a vitamin or mineral or other substance with a nutritional or physiological effect, alone or in combination and is sold in dose form."[1475] The European Commission defines food supplements as "concentrated sources of nutrients (or other substances) with a nutritional or physiological effect. Such food supplements can be marketed in "dose" form, such as pills, tablets, capsules, liquids in measured doses, etc."[1476]

According to the National Health and Nutrition Examination Survey (NHANES), which is conducted annually, about half of American adults use dietary supplements.[1477,1478,1479,1480,1481] And that number is on the rise, particularly among athletes and those with chronic illnesses.[1482,1483,1484] Rates of supplement use also tend to vary based on factors such as income, food security, and participation in food assistance programs (such as SNAP).[1485,1486] Based on 2011-2014 data from NHANES:

> [Dietary supplement (DS)] and [multivitamin-mineral (MVM)] use was significantly higher among those with a household income of ≥ 350% of the poverty level, those who were food secure, and SNAP income-ineligible nonparticipants across all sex, age, and race/ethnic groups. Among women, prevalence of use significantly differed between SNAP participants (39%) and SNAP income-eligible nonparticipants (54%). Older adults (71+ years) remained the highest consumers of DS, specifically among the highest income group (82%), while younger adults (19–30 years), predominantly in the lowest income group (28%), were the lowest consumers.[1487]

Among children, the difference in supplement use by socioeconomic characteristics was similar:

> DS and MVM use were associated with higher family income and higher household food security level. DS use was lowest among children in households participating in the Supplemental Nutrition Assistance Program (SNAP; 20%) and those participating in the Special Supplemental Nutrition Assistance Program for Women, Infants, and Children (WIC; 26%) compared to both income-eligible and income-ineligible nonparticipants. Most children who used DS took only one (83%) or two (12%) products; although children in low-income families took fewer products than those in higher income families. The most common motivations for DS and MVM use were to "improve (42% or 46%)" or "maintain (34 or 38%)" health, followed by "to supplement the diet (23 or 24%)" for DS or MVM, respectively. High-income children were more likely to use DS and MVM "to supplement the diet" than middle- or low-income children. Only 18% of child DS users took DS based on a health practitioner's recommendation. In conclusion, DS use was lower among children who were in low-income or food-insecure families, or families participating in nutrition assistance programs.[1488]

Spotlight: National Institutes of Health Office of Dietary Supplements (NIH ODS) recommendations for taking dietary supplements

The NIH ODS recommends that people who are interested in taking dietary supplements to treat their health conditions keep the following in mind:

- If you are scheduled to have any type of surgical procedure, talk with your health care provider about any supplements you take.
- Keep in mind the term 'natural' doesn't always mean safe. Some all-natural botanical products, for example, like comfrey and kava, can harm the liver. A dietary supplement's safety depends on many things, such as its chemical makeup, how it works in the body, how it is prepared, and the amount you take.
- Before taking any dietary supplement, talk to your health care providers to answer these questions:
  - What are its potential benefits for me?
  - Does it have any safety risks?
  - What is the proper dose to take?
  - How, when, and for how long should I take it?[1489]

The NIH ODS acknowledges the potential health benefits of certain supplements:

- Calcium and vitamin D help keep bones strong and reduce bone loss.
- Folic acid decreases the risk of certain birth defects.
- Omega-3 fatty acids from fish oils might help some people with heart disease.
- A combination of vitamins C and E, zinc, copper, lutein, and zeaxanthin may slow down further vision loss in people with age-related macular degeneration (AMD).[1490]

Furthermore, the NIH ODS notes that consumers should be aware of potential negative interactions between dietary supplements and pharmaceutical medicines:

- Vitamin K can reduce the ability of the blood thinner warfarin to prevent blood from clotting.
- St. John's wort can speed the breakdown of many medicines and reduce their effectiveness (including some antidepressants, birth control pills, heart medications, anti-HIV medications, and transplant drugs).
- Antioxidant supplements, such as vitamins C and E, might reduce the effectiveness of some types of cancer chemotherapy.[1491]

A study appearing in *JAMA Internal Medicine* analyzing three years (2007-2010) of NHANES data submitted by nearly 12,000 patients reported that some individuals were able to articulate specific reasons for taking supplements, including the use of calcium products to promote "bone health."[1511] Most individuals surveyed, however, could only explain their use of dietary supplements in general terms, reporting that they used supplements to "improve" or "maintain" overall health.[1512] Individuals of all ages use supplements. NHANES data from 2006-2014 showed that during that time period, 33.2 percent of children and adolescents in the United States used dietary supplements (particularly multivitamins, supplements for immunity, omega-3 fatty acids, and sleep aids).[1513] However, according to data from the 2017-2018 NHANES, rates of supplement use tend to increase with age.[1514]

Supplement use has also been proposed as a method to combat nutritional insecurity.[1515] The Food and Agricultural Organization of the United Nations and the World Health Organization released a report back in 2006 outlining methods for improving nutritional security globally, and included information about dietary supplements.[1516] The report notes that supplementation programs have been used to improve iron and folic acid levels among children, pregnant women, and postpartum women in developing countries.[1517] However, there are some obstacles facing these dietary supplementation programs as noted in this joint report:

> Supplementation usually requires the procurement and purchase of micronutrients in a relatively expensive pre-packaged form, an effective distribution system and a high degree of consumer compliance (especially if supplements need to be consumed on a long-term basis). A lack of supplies and poor compliance are consistently reported by many supplementation programme managers as being the main barriers to success.[1492]

Despite the prevalence of dietary supplements (which are often food extracts), studies have found that most users are not knowledgeable about the active ingredients, possible side effects, or recommended dosages of what they were taking.[1493,1494,1495,1496] Patients' lack of knowledge seems partially attributable to their lack of communication with medical professionals regarding the potential benefits and risks of supplement use.[1497,1498,1499] Of those who responded to the NHANES surveys between 2007 and 2010, 77 percent had self-prescribed dietary supplements without consulting a healthcare provider.[1500,1501] Many of these individuals further reported that they avoided discussing the use of supplements with their physicians because they felt that their doctors lacked knowledge or were biased against the practice.[1502,1503]

Many patients, physicians, and researchers have questioned the safety of taking dietary supplements.[1504,1505,1506] As mentioned above, the NIH ODS warns patients about the potential negative effects of supplements' interaction with other medicines.[1507] Some researchers argue that there is little benefit at all to taking supplements, and are therefore not worth the potential risk of taking something unknown and potentially harmful.[1508,1509] However, in an 11-year study from 1999 to 2010, published in *Annals of Internal Medicine* in 2019, of 30,899 adults taking supplements, researchers found that use of dietary supplements was not connected to increased mortality.[1510]

Supplement Use Among Athletes

The trend of self-prescription also holds among elite athletes, among whom dietary supplement use is significantly more prevalent

than it is among average Americans.[1518] This heightened frequency of use, however, does not seem to correspond to increased scientific knowledge of how these supplements may impact the body.[1519,1520] In multiple studies conducted from 2003 to 2021, athletes have reported taking supplements to achieve a broad range of health goals, including improved performance, enhanced muscle recovery, and disease prevention[1521,1522,1523,1524,1525,1526,1527]

In a 2019 survey of elite athletes in Spain published in the *Journal of the International Society of Sports Nutrition*, more than 60 percent of respondents stated that they used dietary supplements, including supplements that had little evidence backing their efficacy.[1528] Nearly half of the respondents said that they relied primarily on themselves as sources of information, rather than a physician, nutritionist, or other health care professional.[1529] "This information points towards the necessity of increasing the knowledge of the benefits and risks of supplementation in the elite athlete population," the authors wrote.[1530] In addition, a 2010 study published in *JAMA Internal Medicine* showed that the majority of athletes surveyed did not know the active ingredients or mechanisms of action of the supplements they were taking, and only half of the athletes knew the recommended supplement dosages.[1531] Less than half of these athletes said they consulted their medical providers before starting supplementation.[1532]

Nutraceuticals

The term "nutraceutical" was coined by founder and chairman of the Foundation for Innovation in Medicine, Stephen DeFelice, in 1989 to describe a food or part of a food with therapeutic benefits, particularly in the prevention or treatment of disease.[1533,1534,1535,1536] A 2014 review of studies on nutraceuticals, published in the *International Journal of Preventive Medicine*, defines nutraceuticals as "products, which other than nutrition are also used as medicine."[1537] According to two research scientists in a 2020 editorial in the journal *Nutrients*, "Nutraceuticals and nutrition supplements are collectively referred to as 'dietary supplements,' intended to be taken orally."[1538]

However, there is no official definition of nutraceutical yet accepted by government agencies, health care professionals, and nutrition researchers.[1539,1540] "Currently, nutraceuticals do not have a specific definition distinct from those of other food-derived categories, such as food supplements, herbal products, pre- and probiotics, functional foods, and fortified foods," write researchers in a 2018 review in the *British Journal of Clinical Pharmacology*.[1541] This lack of consensus might lead to confusion about the purpose and efficacy of different products for consumers.[1542] According to the researchers:

> Many studies have led to an understanding of the potential mechanisms of action of pharmaceutically active components contained in food that may improve health and reduce the risk of pathological conditions while enhancing overall well-being. Nevertheless, there is a lack of clear information and, often, the claimed health benefits may not be properly substantiated by safety and efficacy information or in vitro and in vivo data, which can induce false expectations and miss the target for a product to be effective, as claimed.[1543]

According to two research scientists in a 2020 editorial in the journal *Nutrients*, "Nutraceuticals and nutrition supplements are collectively referred to as 'dietary supplements,' intended to be taken orally."[1544]Well-known nutraceuticals include echinacea, green tea, ginseng, glucosamine, omega-3, folic acid, and cod liver oil.[1545]

The majority of nutraceuticals have multiple therapeutic properties and "may be used to improve health, delay the aging process, prevent chronic diseases, increase life expectancy, or support the structure or function of the body."[1558] However, not all nutraceuticals provide the health effects they purport to: in a 2018 systematic review of randomized controlled trials published in the *British Journal of Nutrition* studying the impact of nutraceutical use on cognition among older adults, the researchers "failed to locate sufficient evidence to justify long-term use to improve cognitive function."[1559] The researchers also note that further studies are needed to understand the efficacy of certain nutraceuticals such as folic acid, curcumin, and Yamabushitake mushroom. Furthermore, they write that "the combination of dietary and nutraceutical interventions may be a promising strategy to improve cognitive function."[1560]

Despite the lack of evidence about the impact of certain nutraceuticals on health, the market for these products is growing.[1561] While investigating the commercialization of food and medicine, Lisa Haushofer, MD, PhD, a senior research associate at the Institute for Biomedical Ethics and History of Medicine at the University of Zurich, noted that "the nutraceutical and health foods markets are among the fastest growing and most promising markets worldwide."[1562] According to Precedence Research, a worldwide market research and consulting organization, in 2020 the global nutraceuticals market size was valued at $160.3 billion and is expected to rise to $314.2 billion by 2030.[1563]

Nutraceuticals have steadily grown over the past decade and saw a significant rise in early 2020 from the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which caused the COVID-19 pandemic.[1564] During this time "consumers sought additional protections from viral infection and disease based on the assumption that supplement products may offer health benefits or 'immune-boosting' effects if consumed."[1546,1547,1548,1549,1550] The increased attention paid to these products raised questions about their safety and efficacy in the treatment and prevention of COVID-19.[1551] As noted above in dietary supplements, the NIH ODS cautions patients to be aware of potential harmful side effects from the use of supplements, including nutraceuticals.[1552] As researchers wrote in a 2021 review in the journal *mSystems*:

> Consumers need to be aware of misinformation and false promises surrounding some supplements, which may be subject to limited regulation by authorities. However, considerably more research is required to determine whether dietary supplements and nutraceuticals exhibit prophylactic and therapeutic value against SARS-CoV-2 infection and COVID-19.[1553]

For example, elderberry (which is often hypothesized to have antiviral properties[1554]) has been a nutraceutical of interest in the treatment and prevention of COVID-19.[1555] However, there is little conclusive evidence about its efficacy;[1556] furthermore, elderberry has potentially dangerous side effects (including nausea, vomiting, diarrhea, and others) and cannot be consumed raw or undercooked, so patients should be very cautious with this nutraceutical.[1557]

Spotlight: Food for Specified Health Uses in Japan

Japan was one of the first governments to regulate functional foods and explore the health benefits of foods through robust research and testing.[1565,1566,1567] The Japanese Ministry of Health, Labor, and Welfare oversees the approval process for these foods, which are called Food for Specified Health Uses (FOSHU).[1568,1569] To be approved for a FOSHU label, a food must meet the following requirements:

- "Effectiveness on the human body is clearly proven
- Absence of any safety issues (animal toxicity tests, confirmation of effects in the cases of excess intake, etc.)
- Use of nutritionally appropriate ingredients (e.g. no excessive use of salt, etc.)
- Guarantee of compatibility with product specifications by the time of consumption
- Established quality control methods, such as specifications of products and ingredients, processes, and methods of analysis"[1570]

Furthermore, there are three other types of FOSHU: Qualified (scientific evidence is minimal and has not met the standard for an approved FOSHU), Standardized (functional attributes of ingredients in a product have already been approved as individual FOSHU, and the foods therefore do not always require clinical trials), and reduction of disease risk (there is sufficient clinical evidence that a certain food or ingredient is connected to lowered risk of a certain disease).[1571]

Since 2012, more than 1,000 products have consistently held an approved FOSHU label. [1572,1573] FOSHUs can be approved for certain specified uses: changing gastrointestinal health, lowering blood cholesterol, regulating blood sugar levels, impacting blood pressure, assisting in dental hygiene, aiding in mineral absorption, and encouraging bone growth. [1574, 1575, 1576]

Japan has one of the lowest rates of obesity and highest average lifespans in the world, [1577, 1578] and some researchers have argued that diet play a role in these statistics. [1579, 1580,1581] "We need to increase the evidence base of the impact of the whole Japanese dietary lifestyle on health as well as having specific studies on the functionality and health benefits of individual food items," said Eriko Komiya, Director of Food Cultures Office in the Japanese Ministry of Agriculture Forestry and Fisheries, in an article for *Nature*. [1582]

In addition to increased use of nutraceuticals from the COVID-19 pandemic, several other factors have contributed to the popularity of nutraceuticals as an area of research and treatment. Research has demonstrated that nutraceuticals may have a lower risk of addiction and serious side effects than many current pharmaceutical treatments for pain and serious disease.[1586,1587,1588] (Note that more clinical research is needed to understand the potential use of nutraceuticals in managing pain.)[1589,1590] Given that nutraceuticals are derived from food, they may also be less expensive to produce than most conventional pharmaceuticals.[1591] Finally, the rising interest in nutraceuticals may follow the rising consumer demand in the intersection of food and health.[1592]

Functional Foods

Functional foods, defined by researcher Marcello Nicoletti, a professor of Environmental Biology at Sapienza University of Rome, are "foods or food ingredients that have additional health or physiological benefits over and above the normal nutritional value they provide."[1593] Typically, the distinction between nutraceuticals and functional foods lies in how they are ingested: "nutraceuticals" are supplements that are not consumed as conventional food or drink, whereas "functional foods" are consumed as conventional food or drink.[1594]

While there is no universal and unanimous definition of a functional food, several options in various languages have been proposed to the Food and Agriculture Organization of the United Nations, including:

- A foodstuff that provides a health benefit beyond basic nutrition, demonstrating specific health or medical benefits, including the prevention and treatment of disease.
- Processed foods containing ingredients that aid specific bodily functions in addition to being nutritious.[1583]

Christiani Jeyakumar Henry, PhD, MSc, the director of the Clinical Nutrition Research Centre at the Agency for Science, Technology and Research (A*STAR) in Singapore and the Deputy Executive Director at the Singapore Institute of Food Biotechnology and Innovation (SIFBI), wrote about the start of the functional food movement in the *European Journal of Clinical Nutrition*:

> The conviction to develop functional foods first emerged in Japan in the 1980s when faced with escalating health-care costs. The Ministry of Health and Welfare initiated a regulatory system to approve certain foods with documented health benefits. Its primary objective was to improve the health of the nation's ageing population. In 1984, the Ministry of Education, Science and Culture, an *ad hoc* group in Japan commenced a national project to explore the link between food and medical sciences. The term 'functional food' first appeared in 1993 in the *Nature* news magazine under the heading 'Japan explores the boundary between food and medicine'.[1584]

Dr. Henry, a world renowned expert on functional foods, also described functional foods as the following:

- Conventional food containing naturally occurring bioactive substance. An example could be β-glucan in oat bran to lower blood cholesterol; [Note: β-glucan is a water-soluble dietary fiber found in the cell walls of plants][1585]
- Foods that have been modified, by enrichment or other means, with bioactive substances. An example could be margarine that contains added phytosterol that is known to lower serum cholesterol;

- Synthesized food ingredients, such as some specialized carbohydrates intended to have probiotic effects.
- A functional food can be (1) a natural food, (2) a food to which a component has been added, (3) a food from which a component has been removed, (4) a food where one or more components has been modified, (5) a food in which the bioavailability has been modified or (6) any combination of these.[1595]

Functional foods are often used by consumers seeking optimal health and prevention or treatment of disease, and do not need to be used under the supervision of a health care professional.[1596,1597,1598,1599] For example, probiotics, commonly found in fermented dairy products, are often considered to be functional foods for their benefits to the gastrointestinal tract by balancing the gut microbiome to potentially relieve gastrointestinal discomfort.[1600,1601] Many health care professionals and scientists consider all fruits and vegetables to be functional foods due to their rich amounts of important compounds such as fiber and antioxidants.[1602,1603] Functional foods can also be foods that are fortified or otherwise enhanced with vitamins, nutrients, phytochemicals, or other components that have health benefits.[1604] These are often called "fortified foods," and include milk with added vitamin D, iodized salt, or cereals with added folic acid.[1605,1606]

The FDA has no official definition for "functional food,"[1607] so the phrase often ends up as a marketing term for various food products.[1608] Interest in and demand for functional foods is growing in the United States and globally,[1609] so consumers should be encouraged to inform themselves about the functions and benefits that different foods claim to have.

Additional Examples of Dietary Supplements, Nutraceuticals, and Functional Foods

Certain foods have been proven to support general health in addition to being effective in the treatment, co-treatment, and prevention of specific disease states.[1610,1611,1612] Research has demonstrated that functional dietary changes can impact an individual's heart, brain, and bone health:

- Heart Health: Nuts and seeds have been shown to help lower cholesterol.[1613,1614,1615] Fish oil and olive oil can help reduce inflammation, which is associated with heart disease.[1616,1617] More specifically, fish contains omega-3 fatty acids, which can lower blood fats (triglycerides).[1618,16191620] Whole grains consumption has also been associated with reduced levels of homocysteine,[1621] an amino acid associated with heart disease.[1622]
- Brain Health: Peanuts, eggs, fish, meat, and other foods that are high in choline elevate acetylcholine, a neurotransmitter responsible for healthy mental function.[1623,1624,1625] Vitamin E is a fat-soluble antioxidant that helps protect the fatty environment of the brain.[1626,1627,1628] And whole grains rich in vitamin B, such as brown rice or barley, help reduce levels of homocysteine, which is associated with dementia.[1629,1630,1631] Migraines can be attributed to a diet lacking in folate (found in leafy greens).[1632]
- Bone Health: Calcium fortifies bones, and vitamin D plays an essential role in calcium absorption.[1633] Milk, salmon, and dark green vegetables all contain calcium. Almost all milk sold in the United States is fortified with vitamin D,[1634] and sunlight helps your body create vitamin D.[1635] Magnesium (found in almonds, lentils, seeds, and spinach) works in conjunction with calcium to promote bone health.[1636,1637,1638]

Many dietary supplements, nutraceuticals, and functional foods are used by consumers across the world to help manage their health. The National Institutes of Health has numerous resources that provide current, evidence-based information for consumers and health care providers about many different foods and supplements. Below is information from the National Institutes of Health, including the Office of Dietary Supplements (NIH ODS), the National Center of Complementary and Integrative Health (NCCIH), and the National Library of Medicine, about some popular supplements and functional foods:

- Capsicum: Also known as red pepper or chili pepper, the capsicum plant contains a chemical called capsaicin, which is commonly used to reduce pain from a variety of chronic conditions, including diabetic neuropathy, arthritis, and others.[1639] The National Library of Medicine notes that while capsaicin has also been used for issues such as indigestion problems, "but there is no good scientific evidence for many of these uses."[1640]
- Cranberry: According to the NCCIH, "Historically, cranberry fruits or leaves were used for bladder, stomach, and liver disorders, as well as diabetes, wounds, and other conditions."[1641] Today, cranberry is most often associated with treatment of UTIs, and generally studies show that cranberry products reduce the risk of UTIs; however, there have been inconsistent results among various populations.[1642]
- Garlic: Garlic, a popular cooking ingredient, is also commonly available as a dietary supplement. It is most commonly associated with treating heart and blood conditions, such as high blood cholesterol and high blood pressure.[1643] However, the NCCIH notes that there is conflicting evidence about the impact of garlic on cholesterol and blood pressure.[1644] To read more about garlic as medicine, see the Spotlight on page 32.
- Green Tea: The NCCIH writes, "Green tea as a beverage or dietary supplement is promoted for improving mental alertness, relieving digestive symptoms and headaches, and promoting weight loss."[1645] However, there is insufficient evidence to definitely conclude that green tea is effective for these purposes.
- Niacin: Niacin, also called vitamin B3, is a nutrient with many uses, including assisting the body to turn food into energy, maintenance of genome integrity, control of gene expression, and cellular communication.[1646] It is found in a variety of foods (including animal foods and certain types of nuts, legumes, and grains), but it can also be added to some food products or purchased as a supplement.[1647] Insufficient niacin can lead to a skin condition called pellagra, characterized by a roughened, sunburned-like appearance and pigmented rash.[1648] However, the NIH ODS warns that taking too much niacin can lead to negative side effects such as headaches, rashes, and dizziness.[1649]
- Omega-3 Fatty Acids: Found in foods such as fish and flaxseed, as well as supplements such as fish oil, omega-3 fatty acids are a collection of three fatty acids that partially make up cell membranes.[1650] One of these three acids cannot be produced by the body, so it must come from food; the other two can be produced by the body in very small amounts, so getting them from foods is much more practical.[1651]
- Potassium: Potassium is found in a variety of foods: bananas, potatoes, spinach, kidney beans, and much more.[1652] According to the NIH ODS, "Your body needs potassium for almost everything it does, including proper kidney and heart function, muscle contraction, and nerve transmission."[1653] However, abnormally high levels of potassium, a condition

- called hyperkalemia (most common in people with chronic kidney disease), can cause muscle weakness, numbness, tingling, nausea, and other symptoms in some patients.[1693]
- Probiotics: Probiotics are defined by the NIH ODS as "live microorganisms (such as bacteria and yeasts) that provide health benefits when you consume them."[1694] Probiotic food products include dairy products such as yogurt as well as certain non-dairy fermented foods.[1695] As noted above in Functional Foods, probiotics are often considered to be functional foods for their benefits to the gastrointestinal tract.[1696,1697]
- Vitamin D: Vitamin D is used by the human body for many functions, including calcium absorption, muscle movement, and maintaining the immune system.[1698] According to the NIH ODS, "Very few foods naturally contain vitamin D. " They note, however, that fatty fish, such as trout, salmon, tuna, and mackerel, is a good natural source of vitamin D.[1699] Many foods are thus fortified with vitamin D, such as cow's milk, plant-based milk, and breakfast cereals.[1700]

Note: See Office of Dietary Supplements' Dietary Supplement Fact Sheets, the National Center of Complementary and Integrative Health's Health Topics, and the National Library of Medicine's Medline Plus to learn more about specific foods and supplements.

Although extensive research into the various kinds of nutraceuticals and dietary supplements, their medical applications, and the potential risks associated with their use remains to be done, early studies have shown certain supplements may have potential for managing and treating disease. These include:

- Lowering Cholesterol: Some studies have reported that phytosterols, a component of plant cell membranes commonly used as additives in food products, reduce "bad" low-density lipoprotein (LDL) cholesterol by decreasing the amount the body produces and absorbs into the gastrointestinal tract.[1654,1655,1656,1657,1658] Other nutraceuticals in a few studies have demonstrated potential in reducing cholesterol and include the polyphenols in durian (an edible fruit),[1659,1660] certain kinds of green tea,[1661,1662] Annurca apple polyphenolic extract,[1663,1664,1665,1666] and a formulation that includes berberine ("a chemical found in some plants like European barberry, goldenseal, goldthread, Oregon grape, phellodendron, and tree turmeric," according to the National Library of Medicine[1667]) and red yeast rice.[1668,1669,1670,1671]
- Cancer: Cancer researchers are interested in the potential for nutraceuticals to provide lower-cost, reduced-risk ways of managing and treating the disease. For example, butein is a polyphenol, are "common antioxidants present in a large number of foods and beverages of plant origin," [1672] with a history of use in many East Asian traditional medical practices for its anticancer effects.[1673,1674] In a few studies, butein has been shown to have the ability to induce death in cancer cells.[1675,1676,1677,1678,1679,1680] In addition, phytosterols (plant-derived sterols similar in structure to cholesterol[1681,1682]) in three types of algae have shown anticancer effects in a small group of studies.[1683,1684,1685,1686] There is also interest in finding applications for the management and treatment of cancer in lactic acid bacteria (LAB),[1687,1688,1689,1690,1691] which is prevalent in cultured and fermented foods.[1692]

- Neurological Disorders: Neurological disorders have a variety of causes and risk factors, including stressful life events, psychological comorbidities, advanced age, and smoking .[1701,1702,1703] Over time, the brain undergoes oxidative stress, which plays a key role in numerous neurological disorders, including Alzheimer's disease (AD).[1704,1705] Antioxidants can be found in many food products, including curcumin, which is an antioxidant found in turmeric[1706,1707,1708] and the flavonoids in wine and tea, may, according to some studies, help to slow the progress of AD and similar conditions.[1709,1710,1711,1712] In addition, many neurological disorders, such as Multiple Sclerosis (MS), are caused by improper folding of proteins in the brain, a process that vitamin A,[1713,1714] β-carotene,[1715,1716] and coenzyme Q10 (CoQ10)[1717,1718,1719] all may help to combat.[1720] The decline in function associated with Parkinson's disease (PD) results from a drastic drop in the brain's dopamine levels, and lycopene, an antioxidant found in tomatoes, papayas, and other red fruits and vegetables, has been shown to increase dopamine in mice, suggesting it may have potential for managing the disease in humans.[1721,1722,1723]

- Inflammation: Certain nutraceuticals have proven effective as anti-inflammatories, showing potential on diseases such as cancer, neurological disorders, and arthritis.[1724,1725,1726] For example, ergosterol from edible mushrooms has been shown to reduce inflammatory responses,[1727,1728,1729] as have lactic acid bacteria[1730] and some chemical compounds such as tocopherols and tocotrienols in the vitamin E family, found in seeds, nuts, and many vegetables.[1731] Polyphenols, found in olive oil, cocoa, and berries, have been found to have anti-inflammatory properties in the treatment of a wide range of diseases;[1732,1733] and curcumin, a polyphenol found in turmeric, has also been found to have capabilities in both the prevention and treatment of inflammatory conditions.[1734,1735,1736]

Regulation of Dietary Supplements, Nutraceuticals and Functional Foods

Unlike pharmaceuticals, which are significantly regulated by the FDA, dietary supplements do not require FDA approval.[1737,1738] Marketers are allowed to make statements about the potential health benefits of the supplement, however, the following qualifier is required: "This statement has not been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure, or prevent any disease."[1739] (According to a 2019 review of labeling impacts on consumer behavior in *The Journal of Alternative and Complementary Medicine*, "Many consumers did not regularly read product labels, nor understand the information they read on those labels."[1740]) The lack of regulation has led to the production and sale of supplements that do not always contain the ingredients and quantities that the labels say they do.[1741,1742] Third party groups, such as United States Pharmacopeia (USP) and NSF International,[1743,1744] have thus stepped in to test various dietary supplements (including vitamins, minerals, herbal supplements, and others) and verify what exactly is in them.[1745,1746] Consumers therefore are encouraged to take special caution when choosing to take dietary supplements.[1747]

Furthermore, as mentioned earlier in this report, the terms "nutraceutical" and "functional food" have no formal definitions from the FDA.[1748,1749] Instead, these products are regulated as drugs, dietary supplements, or foods, depending on their ingredients and intended use.[1750] As researchers for the the *British Journal of Pharmacology* wrote in 2016:

> The terms “nutraceutical” and “functional food” are often used interchangeably and have no legal definition in most countries. These products are intended to have health benefits in addition to their basic nutritional value and usually contain ingredients which are referred to as generally recognized as safe (GRAS) in the United States and elsewhere and as qualified presumption of safety (QPS) in the European Union (EU).[1760]

The lack of standards and regulations has led to the dissemination of misinformation by supplement companies and confusion among consumers.[1761,1762] In 2019, the FDA issued a warning to 12 dietary supplement companies, telling them to stop making claims that their products could cure various diseases, most notably Alzheimer’s.[1763] Scott Gottlieb, MD, former commissioner of the FDA, said about the warning, “[U]nproven supplements that claim to treat the disease but offer no benefits can prevent patients from seeking otherwise effective care.”[1764]

Warnings such as these shed light on the need for stricter regulation in this industry.[1765] Establishing standards for testing and proving the safety and efficacy of dietary supplements, nutraceuticals and functional foods is critical to advancing the research into their potential as treatments for disease alongside conventional pharmaceuticals.[1766,1767] Such peer-reviewed scientific research and governmental regulation would also help to distinguish legitimate claims made for the efficacy of these types of treatments from unsubstantiated claims made on behalf of dietary supplements.[1768]
Conversations about the regulation of functional foods and nutraceuticals are not limited to the United States.[1769] In Canada, functional foods and nutraceuticals such as probiotics or herbal supplements are regulated as “natural health products.”[1770] These regulations exist to help consumers make more informed decisions about the treatments they pursue for their specific condition,[1751] but the regulations have received criticism from Canada’s food industry for potentially stifling innovation.[1752]

In the European Union, discussions are ongoing in the European Parliament (EP) as to whether nutraceuticals are medicinal products, defined by the legislative body as “any substance or combination of substances presented as having properties for treating or preventing disease in human beings.”[1753] The debate is not regarding whether food products can have beneficial impacts on human health or not, but whether they have sufficient medical properties for that to be considered their primary function.[1754] Lex Mundi, a worldwide network of independent law firms, released a report in 2012 outlining policy regulations of food supplements in various countries around the world.[1755]

In 2005, the Codex Alimentarius Commission (CAC), established by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO), developed the “Guidelines for Vitamin and Mineral Food Supplements” and adopted them into the Codex Alimentarius,[1756,1757] an international collection of standards, guidelines and codes of practice about food and food safety.[1758] (See Part 2 to learn more about the Codex Alimentarius.)

According to a 2018 review in the *Annual Review of Public Health*, the “Guidelines for Vitamin and Mineral Food Supplements” “apply only to supplements that contain vitamins and/or minerals where these products are regulated as foods, and they address the composition of supplements, including their safety, purity, and bioavailability.”[1759] Note that these guidelines do not include regulations for products such as functional foods, herbal supplements, fatty acids, or amino acids. The guidelines define vitamin and mineral food supplements as products that:

> …derive their nutritional relevance primarily from the minerals and/or vitamins they contain. Vitamin and mineral food supplements are sources in concentrated forms of those nutrients alone or in combinations, marketed in forms such as capsules, tablets, powders, solutions, etc., that are designed to be taken in measured small-unit quantities but are not in a conventional food form and whose purpose is to supplement the intake of vitamins and/or minerals from the normal diet.[1771]

These Guidelines were developed to establish international agreement about the composition, packaging, and labeling of vitamin and mineral supplements.[1772] However, the Codex Alimentarius has no regulatory power, and therefore countries are not obligated to enforce any guidelines included in it.[1773] Still, at the time, American consumers were concerned, as a result of these concerns, the FDA gave assurances that the adoption of the Guidelines for Vitamin and Mineral Food Supplements “will not restrict U.S. consumers’ access to vitamin and mineral supplements or impose any restrictions that go beyond those established by U.S. law.”[1774]
In a review of nutraceutical regulation for the *British Journal of Pharmacology*, researchers from the University of Napoli Federico II, the Italian Medicine Agency, and the University of Miami write:

> ...a restructuring of the entire regulatory framework of dietary supplements in view of the role of nutraceuticals is deemed necessary to first give credit to their different purposes and definition, and second, to assess their specific role in the prevention and treatment of pathological conditions, supporting their potential medical use in prevention and therapy only when proven by sound scientific and clinical data.[1775]

Clear definitions and regulation of functional foods and nutraceuticals will help improve consumer understanding of the effects of their food choices on their health while simultaneously promoting the expansion of evidence-based food as medicine practices and programs.[1776]

Furthermore, there are three other types of FOSHU: Qualified (scientific evidence is minimal and has not met the standard for an approved FOSHU), Standardized (functional attributes of ingredients in a product have already been approved as individual FOSHU, and the foods therefore do not always require clinical trials), and reduction of disease risk (there is sufficient clinical evidence that a certain food or ingredient is connected to lowered risk of a certain disease).[1777]

Since 2012, more than 1,000 products have consistently held an approved FOSHU label.[1778,1779] FOSHUs can be approved for certain specified uses: changing gastrointestinal health, lowering blood cholesterol, regulating blood sugar levels, impacting blood pressure, assisting in dental hygiene, aiding in mineral absorption, and encouraging bone growth.[1780,1781,1782]

Japan has one of the lowest rates of obesity and highest average lifespans in the world,[1783,1784] and some researchers have argued that diet play a role in these statistics.[1785,1786,1787] “We need to increase the evidence base of the impact of the whole Japanese dietary lifestyle on health as well as having specific studies on the functionality and health benefits of individual food items,” said Eriko Komiya, Director of Food Cultures Office in the Japanese Ministry of Agriculture Forestry and Fisheries, in an article for *Nature*.[1788]

Medical Foods

Medical foods are defined by the FDA as foods "formulated to be consumed or administered enterally under the supervision of a physician and which [are] intended for the specific dietary management of a disease or condition for which distinctive nutritional requirements, based on recognized scientific principles, are established by medical evaluation."[1789] These foods are exempt from usual health claim regulation for foods, and the FDA does not maintain a comprehensive list of approved medical foods.[1790]

Medical foods are meant to be consumed under the supervision of a physician by patients who have "limited or impaired capacity to ingest, digest, absorb, or metabolize ordinary foodstuffs or certain nutrients, or who has other special medically determined nutrient requirements, the dietary management of which cannot be achieved by the modification of the normal diet alone."[1791] Generally, though, medical foods do not require a prescription to be purchased; instead, health insurance companies might require a physician's order or issuance in order to cover the cost of the product.[1792] According to the book Developing New Functional Food and Nutraceutical Products:

> [The] FDA narrowly defines the conditions under which a medical food may be marketed:
>
> 1. It must be a specially formulated and processed product (as opposed to a naturally occurring foodstuff used in its natural state) for the partial or exclusive feeding of a patient by means of oral intake or enteral feeding by tube;
>
> 2. It must be intended for the dietary management of a patient who, because of therapeutic or chronic medical needs, has limited or impaired capacity to ingest, digest, absorb, or metabolize ordinary foodstuffs or certain nutrients, or who has other special medically determined nutrient requirements, the dietary management of which cannot be achieved by the modification of the normal diet alone;
>
> 3. It must provide nutritional support specifically modified for the management of the unique nutrient needs that result from the specific disease or condition, as determined by medical evaluation;
>
> 4. It must be intended to be used under medical supervision; and
>
> 5. It must be intended only for a patient receiving active and ongoing medical supervision wherein the patient requires medical care on a recurring basis for, among other things, instructions on the use of the medical food.
>
> In terms of ingredients that may be used in medical foods, the ingredients should be either (1) a food additive used in accordance with FDA's food additive regulations; (2) a color additive used in accordance with the color additive regulations; (3) a substance that is generally recognized, by qualified experts, to be safe under the conditions of its intended use (GRAS); or (4) a substance that is authorized by a prior sanction issued by FDA.[1793]

Some examples of medical foods include formulas for enteral administration (feeding tubes)[1794] and infant formula.[1795] *Today's Dietitian* provides further examples:

- products with a full complement of nutrients except the offending nutrient (eg, phenylalanine or tyrosine), including Lofenalac, Ketonex-2, or Propimex;
- modular products, such as ready-to-drink beverages, tablets, and amino acid mixtures, including GlutarAde and Foltx.[1796]

Food Interventions, Reimbursement, and Health Insurance

From the late 2000s to the early 2010s, health insurers have come under scrutiny for spending less on care and more on lobbying and marketing costs in order to increase profits.[1797,1798,1799,1800] The Affordable Care Act, passed in 2010, attempted to curtail this trend by requiring that companies spend 80 percent of premiums they receive on patient claims.[1801,1802,1803,1804,1805] Many companies have responded by simply raising their premiums, thus increasing the amount of money they get to keep for administrative uses and as profit.[1806] Health insurers have also been implicated in agreements with client hospitals that set inflated rates for medical care, causing the United States to spend more on health care per person than any other developed nation, according to statistics from the Organisation for Economic Co-operation and Development, an international economic organization with 35 member states.[1807] And, in another alarming trend, the COVID-19 pandemic has seen many of the nation's largest insurance companies, including Humana, Anthem, and UnitedHealth Group, double their earnings.[1808]

Some insurance plans, well aware of the healthcare costs associated with poor diet, have started to include financial coverage for food interventions, including meals and groceries.[1809,1810,1811] "[I]nsurers... have to accurately predict how much the people they insure will cost. That way they can set premiums to cover those costs," wrote journalist Marshall Allan for *NPR*.[1812] Since the Affordable Care Act requires health insurance companies to spend at least 80 percent of premiums on care (rather than administrative costs),[1813] higher healthcare costs (resulting from rising rates of diet-related disease) could complicate these calculations for some insurance companies and cut into their profits.[1814]

Numerous health insurers across the country have begun coverage for food interventions, such as home-delivered meals, healthy grocery stipends, and nutrition education.[1815,1816] Food interventions provided through the healthcare system can help patients manage their chronic disease while simultaneously addressing food insecurity.[1817,1818] "[F]inancial support for food is medicine interventions in the healthcare

system might be effective and expedient ways to improve both food insecurity and health, even if they do not comprehensively tackle the root structural causes of suboptimal diet," write researchers led by Sarah Downer, Clinical Instructor at the Center for Health Law and Policy Innovation of Harvard Law School and Director of the Center's Whole Person Care Initiative, for the *BMJ*.[1819] The authors note that this financial support can come from health insurers:

> In the U.S., government and private health insurers are adopting food and nutrition interventions in the hope of a return on their investment due to reductions in high expenditure healthcare claims. In light of emerging evidence, policy makers are experimenting with loosening the parameters of value based or capitated payment structures to allow public insurance money to be spent on food is medicine interventions. This flexibility can be expanded, administratively or through legislation, to all public health insurance programmes. However, large scale uptake of newly created flexibility to pay for food depends on confidence that food is medicine interventions are clinically effective and cost effective compared with other aspects of medical care.[1820]

Access to nutritious food is considered a social determinant of health by the U.S. Department of Health and Human Services' Healthy People 2030.[1821] (According to the U.S. Department of Health and Human Services: "Social determinants of health [SDOH] are the conditions in the environments where people are born, live, learn, work, play, worship, and age that affect a wide range of health, functioning, and quality-of-life outcomes and risks."[1822]) Therefore, covering the cost of nutritious food may be a way for health insurance companies to reduce clients' health care costs by improving their food security and, ultimately, their health.[1823,1824,1825]

Conflicts of Interest: Health Insurance Companies and the Fast Food Industry

It is also important to note the significant financial investments that some health and life insurers have in the fast food industry.[1826] A 2010 study in the *American Journal of Public Health* found that insurers such as Metlife (life, dental, disability, and critical illness insurance), Prudential (life insurance), New York Life (life insurance), Northwestern Mutual (life, disability, and long-term care insurance), among others, have millions of dollars in holdings in fast food companies such as McDonald's, Jack in the Box, and Burger King.[1827] Frequent fast food consumption has been linked to poor health and increased risk of diet-related disease such as diabetes and obesity.[1828,1829,1830] In the journal *Nutrition Reviews* in 2013, researchers wrote:

> Consumption of takeaway and fast food has been shown to have adverse health effects, and while the majority of studies on this subject have focused on the relationship between fast food consumption and weight gain,[1831,1832,1833] more frequent consumption of meals prepared outside of the home has also been observed to correspond with increased risk of insulin resistance, type 2 diabetes, elevated total cholesterol, and low-density lipoprotein cholesterol (LDL-C) levels as well as decreased high-density lipoprotein cholesterol (HDL-C) concentrations.[1834,1835,1836] Takeaway or fast food consumers are characterized by higher intakes of energy, fat, saturated fatty acids (SFAs), trans fatty acids (TFAs), added sugar and sodium, and lower intakes of fiber, macronutrients, and vitamins in comparison to those who do not eat food prepared outside the home.[1837,1838,1839,1840,1841]

Wes Boyd, MD, PhD, a professor of Medical Ethics and Psychiatry at Baylor College of Medicine, and one of the co-authors of the aforementioned *American Journal of Public Health* study, said, "If the insurance industry is willing to invest in products known to be harmful and/or kill people then, prima facie, this is not an industry that actually cares about health and well-being."[1842] Spokespeople for some of the companies mentioned in the article disputed the claims.[1843]

The authors concluded that there are two ethical options for insurers to consider regarding their investments:

> The first is to divest themselves of holdings in fast food companies as well as other industries that have a clearly negative public health impact. Socially responsible investment funds have shown that profits are not incompatible with social good.
>
> A second option is that insurers could mitigate the harms of fast food by leveraging their positions as owners of fast food companies to force the adoption of practices consistent with widely accepted public health principles. Such moves could include encouraging companies to improve the nutritional quality of their products, reduce calorie density, serve smaller portions, and change marketing practices. To maximize their impact, insurers might turn over their proxy votes to an independent nonprofit organization that could pool votes in a way that effects meaningful change.[1844]

Health Insurance Plans Adopting Food as Medicine Programs

Several health insurers, both public and private, have incorporated food as medicine coverage in their plans. See below for a list of programs and plans that include food interventions.

Medicaid: Numerous state Medicaid programs have incorporated food interventions in their coverage, including Virginia, Michigan, and North Carolina.[1845] In Virginia, various Medicaid Managed Care programs include benefits such as home-delivered meals and free transportation to farmers' markets and grocery stores.[1846] Michigan has a policy that requires their Medicaid contractors to measure and report on food access for clients, as well as provide resources to clients to help them access food.[1847] North Carolina's Medicaid program includes an initiative called "Healthy Opportunities," which provides funding to various non-medical pilot programs to improve health, including food interventions such as healthy food boxes, fruit and vegetable prescriptions, healthy meals, and medically tailored meals.[1848,1849]

Medicare Advantage: As of 2019, more than 20 million people were enrolled in a Medicare Advantage program (sometimes called "Part C" or "MA Plans"), a type of health insurance that provides Medicare benefits through contracting a private health insurance company.[1850] According to the Kaiser Family Foundation, almost half (46 percent) of Medicare Advantage plans offer some type of meal benefits,[1851] such as nutrition education, cooking classes, or meal delivery.[1852] These nutrition related programs are part of Medicare Advantage's attempt to increase their available "health-related benefits" in order to improve patient health and lifestyle before they even go to the doctor.[1853] One study of these programs in the journal *Health Affairs* found that participants in a meal delivery program required fewer emergency health services.[1854]

Oscar Health: At the outset of the COVID-19 pandemic, Oscar Health reported that 30 percent of their Medicare Advantage customers had food supply problems, and they responded to this obstacle by arranging complimentary grocery deliveries from local

grocery stores.[1855] The insurer acknowledges the steep costs of hospital visits and believes that training people to eat a more nutritious diet is a cheaper alternative to costly medical care.[1856] Ananth Lalithakumar, an executive at Oscar Health, stated that, "We've seen time and again, the lack of food and nutritional food causes members to get readmitted" to hospitals.[1857]

Health Partner Plans: In 2015, Health Partners Plans (HPP), a Philadelphia-based insurance company, piloted a medically tailored meal program among 30 people who were living with diabetes.[1858] The 30 enrollees received three meals per day and were supported by phone by case managers. The results were so successful that HPP transformed the pilot into an established program.[1859] As of July 2018, the program had delivered 610,500 meals to more than 2,400 members, more than 13 percent of whom were people with diabetes. Tracking outcomes, they found that hospital admissions dropped nearly 28 percent, emergency room visits nearly 7 percent, primary care visits nearly 16 percent, and visits to specialists over 7 percent.[1860] As of November 17, 2021, Health Partners Plans and Metropolitan Area Neighborhood Nutrition Alliance delivered one million medically tailored meals to its Medicaid members.[1861]

Healthfirst and MetroPlus: In early 2021, Healthfirst, one of the nation's largest not-for-profit health insurers, partnered with the NYC-based nonprofit GrowNYC to allow members of certain Medicare Advantage dual-eligible plans to purchase fresh fruits and vegetables at farmers' markets run by GrowNYC.[1862,1863] Members can use cards provided by Healthfirst to purchase coupons that can then be used for the purchase of any fruits and vegetables at GrowNYC markets. The nonprofit has also made these coupons available to members of MetroPlus Medicare.[1864]

Humana: Health insurance company Humana has a few programs that integrate food and medicine. In an interview with the Associated Press, Andrew Renda, MD, MPH, Vice President of Bold Goal and Population Health Strategy at Humana, said that there is research demonstrating that diabetes patients make visits to the emergency room when access to food is difficult: "It may be because they're still taking their medications but don't have enough food, so that their blood sugar goes crazy and then they end up in the hospital."[1865] One of the programs offered by Humana to address this problem is called the Well Dine program:

> Well Dine delivers fully prepared, nutritious meals to eligible Humana Medicare-covered patients recovering at home from an inpatient stay in a hospital or skilled nursing facility (SNF) or enrolled in a qualified chronic-condition special needs plan (SNP), dual-eligible SNP or Illinois Medicare-Medicaid plan. Patients also receive a guide to nutrition and eating well.
>
> Meals are provided by a Humana vendor and delivered by FedEx or UPS. Post-discharge meals must be ordered within 30 days of the patient's post-discharge date. The number of meals provided depends on the patient's plan benefits. There may be a limit to how many times the benefit can be used each year.

Patients who are eligible for the chronic-condition meals program receive 20 meals designed to support their special dietary needs. Patients with multiple conditions can receive 20 meals per eligible condition during the plan year. Eligible conditions may include congestive heart failure, coronary artery disease, and diabetes.[1866]

Another program offered by Humana is the Healthy Foods Card, which allows members to purchase approved foods (including perishable foods, nonperishable foods, frozen foods, and beverages) from specific retailers.[1867] The card acts like a debit card loaded with $25 or $50 per month.[1868] This benefit is available to enrollees in Humana's Medicare Advantage plans.

Blue Cross Blue Shield: Health Care Service Corporation, the parent company of Blue Cross Blue Shield in Texas, Oklahoma, New Mexico, Montana, and Illinois, launched a prepared meal delivery pilot program, called FoodQ, for residents of 25 Illinois zip codes and 15 Dallas zip codes.[1869] Many of the residents of the chosen zip codes have difficulty accessing nutritious food because of transportation barriers or a lack of availability of nutritious foods in their communities.[1870] Recipients could purchase meals for $5-$10 each, and pay a $10 per month subscription fee to avoid delivery charges.[1871] The program ran for six months in 2019; however, at the time of publication (February 2022) the FoodQ website is not operational.[1872]

Blue Shield of California: In 2021, health insurance company Blue Shield of California (an independent member of the Blue Shield Association) expanded its Wellvolution lifestyle program (a platform that connects participants with curated programs to manage a "healthy lifestyle," such as weight loss, mental health, and smoking)[1873] to include nutrition support for members living with type 2 diabetes.[1874] Low-income members of Blue Shield are eligible to receive six months of free diabetes-friendly meals provided by health care company Betr Health.[1875,1876]

Government Support for Food as Medicine

In addition to health care organizations, some policymakers and legislators have introduced and supported food as medicine programs on local, state, and federal levels. In 2019, the Center for Health Law & Policy Innovation at Harvard Law School and medically-tailored meal nonprofit Community Servings released the Massachusetts Food is Medicine State Plan.[1877] Sponsored by State Senator Julian Cyr (D-MA) and State Representative Denise Garlick (D-MA), the plan advocated for the Office of Medicaid (MassHealth) to create a food and health pilot program that would connect Medicaid enrollees with diet-related diseases to community-based nutrition organizations.[1878] The authors of the plan estimate that food insecurity, hunger, mental health and the physical health conditions to which they contribute currently cost the state of Massachusetts approximately $1.9 billion annually.[1879] The goal of the program would be to reduce those costs while also achieving better health outcomes for patients.[1880,1881]

Interest and action surrounding the use of food as medicine has also reached the federal level. In January 2018, the House of Representatives created a bipartisan Food is Medicine Working Group led by Representatives Jim McGovern (D-MA), Chellie Pingree (D-ME), Roger Marshall (R-KS), and Jackie Walorski (R-IN) whose purpose is to draw attention to hunger and address its impacts on health.[1882] One of the Food is Medicine Working Group's key goals is to shape policy that would secure medically tailored meals made with fresh fruits and vegetables for more chronically-ill Americans. "We simply cannot address hunger and health as two separate issues," said McGovern at an event celebrating the program's launch, "They're two sides of the same coin."[1883] Over the few years since its launch, the group has made notable progress. In 2020, it introduced the Medically Tailored Home-Delivered Meal Demonstration Pilot Act, which, if passed, would establish a 3-year pilot program assessing the impact of providing MTMs to vulnerable older adults through Medicare.[1884,1885]

As the momentum behind using nutrition as a tool for improving public health builds, universities have begun working with policymakers to devise healthier federal food programs.[1886] Tufts University's Food is Medicine Public Impact Initiative is a notable example of this type of collaboration.[1887] Led by faculty at the Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy, the oldest and largest graduate school of nutrition in North America, the initiative aims to "raise awareness of the tremendous impact of food on national well-being... and provide trusted science on actionable and impactful solutions."[1888] In conjunction with Congressional leaders, community advocates, and industry stakeholders, the researchers hope to create policy solutions that improve nutrition for all Americans, reduce the cost of their care, and mitigate health inequities by using food as medicine.[1889]

Part IV

Food as Medicine Treating and Managing Disease

PART IV

Food as Medicine: Treating and Managing Disease

Research has demonstrated that a nutritious diet can have a significant impact on the prevention, treatment, and outcome of many disease states.[1890,1891,1892,1893,1894,1895,1896,1897,1898,1899] This section provides an overview of dietary interventions that have been studied in the treatment, co-treatment, and management of specific conditions and diseases.

The conditions and diseases included in this section are:

- Alzheimer's
- Arthritis, Non-Rheumatoid
- Arthritis, Rheumatoid
- Autism
- Cancer
- Chronic Kidney Disease
- Cirrhosis and Ascites
- Diabetes
- Inflammatory Bowel Diseases
- HIV/AIDS
- Hypertension
- Mental Health Conditions and Illnesses
- Multiple Sclerosis
- Sleep

Alzheimer's

According to the National Institutes of Health National Institute on Aging (NIA):

> Alzheimer's disease is a brain disorder that slowly destroys memory and thinking skills and, eventually, the ability to carry out the simplest tasks. In most people with the disease—those with the late-onset type symptoms first appear in their mid-60s. Early-onset Alzheimer's occurs between a person's 30s and mid-60s and is very rare. Alzheimer's disease is the most common cause of dementia among older adults.[1900]

Common Dietary Interventions

Facets of the ketogenic and Mediterranean diets are among the most common dietary changes used as part of a treatment plan for many diet-related diseases[1901,1902,1903,1904] and are referenced often in the following section.

The ketogenic diet was first introduced in the early 1920s as a treatment for epilepsy and has also been examined in the treatment of a variety of diet-related health conditions.[1905] The ketogenic diet is a low carbohydrate, high fat diet that focuses on replacing carbohydrates and sugars your body can break down easily (such as white bread and soda) with a moderate amount of proteins (e.g grass-fed beef and free-range poultry) and a high amount of healthy fats (e.g. avocado).[19061907,1908,1909] While there is not a standard macronutrient profile for the ketogenic diet, "The dietary macronutrients are divided into approximately 55% to 60% fat, 30% to 35% protein, and 5% to 10% carbohydrates. Specifically, in a 2000 kcal per day diet, carbohydrates amount up to 20 to 50 g per day."[1910] This mix of macronutrients aims to induce ketosis, a metabolic state in which your body uses fat for fuel instead of carbohydrates.

The Mediterranean diet consists of foods that are consumed in regions surrounding the Mediterranean Sea, including local, fresh produce; extra virgin olive oil; small amounts of cheese, yogurt and red meat; fish and poultry; desserts made up of fresh fruit; and moderate amounts of wine consumed with meals.[1911,1912] The Mediterranean diet is included on the United Nations Education, Scientific and Cultural Organization (UNESCO)'s list of Intangible Cultural Heritage of Humanity.[1913] According to The Mediterranean Diet, the website charged with "safeguard[ing] and promot[ing] the Mediterranean Diet at the regional, national and international level,"[1914] followers of the diet should use the official diet pyramid, which "places at the base foods of plant origin that provide key nutrients and other protective substances that contribute to general well-being and to maintain a balanced diet."[1915]

Estimates from experts suggest that more than 6 million Americans over the age of 65 might have Alzheimer's,[1916] and the Alzheimer's Association projects this number to grow to nearly 14 million by 2050.[1917] Alzheimer's disease is characterized by a "loss of cognitive functioning — thinking, remembering, and reasoning — to such an extent that it interferes with a person's daily life and activities."[1918]

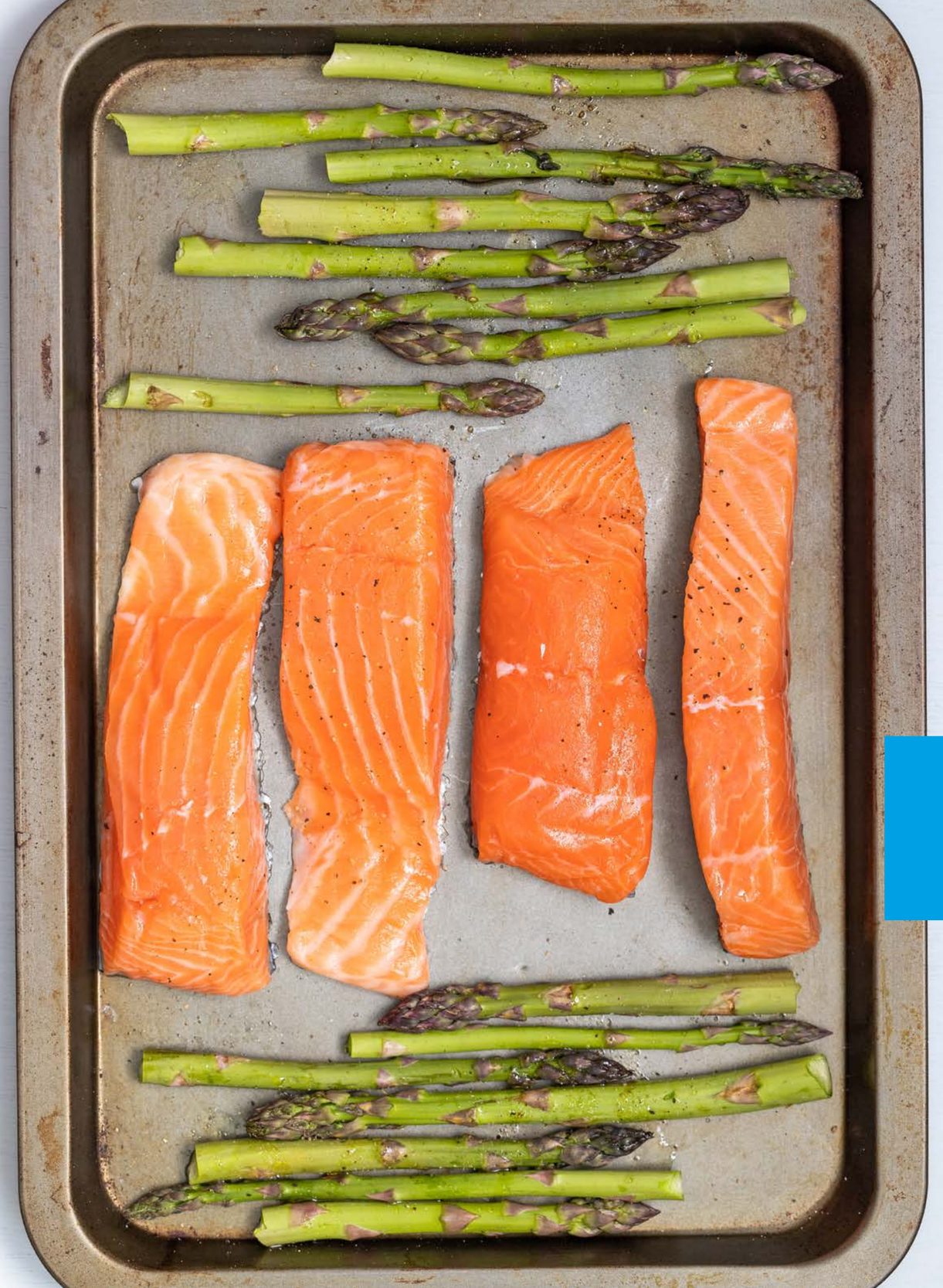
The NIA states that the Mediterranean diet (high in fish, whole grains, vegetables, and olive oil while low in red meat consumption) has been associated with cognitive benefits in reducing the risk and effects of Alzheimer's.[1919] A 2021 study in *Neurology* showed that the Mediterranean diet could act as a protective measure against memory decline in older adults at high risk of developing Alzheimer's (researchers cited the following risk factors for Alzheimer's: relatives with Alzheimer's, subjective cognitive decline, and mild cognitive impairment).[1920] In a 2020 study appearing in *Alzheimer's & Dementia*, older individuals (age 50-85) were given cognition tests and food frequency questionnaires to determine the connections between dietary intake and cognitive function.[1921] In the study, researchers found that participants whose diets were most similar to the Mediterranean diet scored higher on cognition tests.[1922]

The DASH (Dietary Approaches to Stop Hypertension) diet has been shown to lower high blood pressure, a risk factor for Alzheimer's disease.[1923] The DASH diet includes: "Eating vegetables, fruits, and whole grains; including fat-free or low-fat dairy products, fish, poultry, beans, nuts, and vegetable oils; limiting foods that are high in saturated fat, such as fatty meats, full-fat dairy products, and tropical oils such as coconut, palm kernel, and palm oils; and limiting sugar-sweetened beverages and sweets."[1924]

The MIND (Mediterranean–DASH Intervention for Neurodegenerative Delay) diet combines elements of both the DASH diet and the Mediterranean diet. Similarly to those diets, the MIND diet emphasizes fruits, vegetables, whole grains, nuts, beans and certain fish.[1925] The diet focuses on plant-based foods linked to dementia prevention.

According to the NIA, the MIND diet emphasizes eating from 10 healthy food groups as follows:

- Leafy green vegetables, at least 6 servings/week
- Other vegetables, at least 1 serving/day
- Berries, at least 2 servings/week
- Whole grains, at least 3 servings/day
- Fish, 1 serving/week
- Poultry, 2 servings/week
- Beans, 3 servings/week
- Nuts, 5 servings/week
- Wine, 1 glass/day
- Olive oil
- [Set limits for] red meat, sweets, cheese, butter/margarine and fast/fried food.[1926]



According to the NIA, “Evidence supporting the MIND diet comes from observational studies of more than 900 dementia-free older adults, which found that closely following the MIND diet was associated with a reduced risk of Alzheimer’s disease and a slower rate of cognitive decline.”[1927] A forthcoming 3-year study will examine the impact of these diets on brain health and cognitive decline among older adults with a family history of dementia or Alzheimer’s.[1928] The study is supported by the MIND Diet Intervention, a collaboration between Rush University, Harvard T.H. Chan School of Public Health, Brigham & Women’s Hospital, and the National Institute on Aging.[1929]

There is a plethora of research demonstrating that oily fish (e.g., salmon) is associated with lower cognitive decline and higher brain function.[1930,1931,1932,1933,1934,1935,1936,1937] This could be due to the omega-3 fatty acids in fish, nutrients present in high quantities in the brain.[1938] In a 2018 study of patients diagnosed with Alzheimer’s at varying levels of severity appearing in the *Journal of Alzheimer’s Disease*, dietary intervention in the form of fish oil intake was associated with slower progression of the disease, including improved memory, sight, and mood.[1939] In 2019, another study appearing in *PLoS One* concluded that fish oil supplementation might have neuroprotective effects when taken during the presymptomatic stage of Alzheimer’s.[1940]

Some studies have demonstrated the ketogenic diet to be a potentially effective therapy in both the prevention and treatment of Alzheimer’s.[1941,1942,1943,1944] In one study published in *Alzheimer’s Research & Therapy* in 2021, researchers found that a 12-week modified ketogenic diet (macronutrient ratio of 58% fat, 29% protein, 7% fiber, and 6% net carbohydrate by weight) significantly improved total quality of life and daily function among patients with clinically confirmed Alzheimer’s .[1945] Specifically, memory retention rates, adherence, and safety were all more achievable in Alzheimer’s patients who were on the ketogenic diet.[1946]
When designing dietary changes for patients managing Alzheimer’s, there are other variables that need to be considered to ensure that food is both appealing and easy to eat.[1947] Cognitive decline in patients with Alzheimer’s has been linked to masticatory function decline,[1948] which means that they often have difficulty chewing. Loss of appetite is also common among Alzheimer’s patients.[1949] Furthermore, many medications prescribed to treat Alzheimer’s have side effects that adversely affect the gastrointestinal system.[1950] While the triggers for gastrointestinal pain and discomfort vary widely among different people,[1951] some studies have shown that intake of dietary fiber (often from fruits and vegetables) might help patients who are experiencing gastrointestinal discomfort.[1952,1953,1954]

Current evidence about the connection between diet and Alzheimer’s risk is not as strong as evidence for other types of lifestyle interventions, such as physical activity and cognitive testing.[1955] However, research into the effects of various types of foods and dietary interventions on brain health is still ongoing,[1956] as well as the risk factors associated with obesity, alcohol consumption, and smoking.[1957]

Arthritis, Non-Rheumatoid

According to the National Institutes of Health National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), "'Arthritis' literally means joint inflammation. Although joint inflammation is a symptom or sign rather than a specific diagnosis, the term arthritis is often used to refer to any disorder that affects the joints. Joints are located in -places where two bones meet, such as your elbow or knee."[1958] Arthritis refers to more than 100 different diseases characterized by joint pain, swelling, and stiffness; this includes osteoarthritis, gout, psoriatic arthritis, and rheumatoid arthritis, among others.[1959,1960] Arthritis can affect people of any age, sex, and race, but is most prevalent among women and older people.[1961]

Osteoarthritis

According to the Centers for Disease Control and Prevention (CDC), osteoarthritis is the most common type of arthritis caused by damage or breakdown of joint cartilage between bones.[1962] In some studies, the Mediterranean diet has been shown to help alleviate pain for people with osteoarthritis due to its anti-inflammatory effects.[1963,1964,1965,1966,1967] Eating a diet that is high in fiber such as vegetables, beans, whole grains and fruit has been associated with decreased inflammation. In two long-term observational studies of individuals with knee osteoarthritis published in *Annals of the Rheumatic Diseases*, researchers found that higher total fiber intake correlates with lower prevalence of the disease.[1968]

Consumption of various fruits and fruit extracts, especially berries high in antioxidants (such as blueberries, raspberries, and strawberries), may reduce pain and inflammation; according to a 2019 review in *Food & Function*, "on the basis of emerging pre-clinical, epidemiological and clinical data, blueberries, raspberries and strawberries, as well as pomegranates are among the commonly available fruits that may offer some protection against arthritis."[1969] In one 2015 study published in the journal *Arthritis,* a whole-food, plant-based (WFPB) diet was found to reduce pain for osteoarthritis patients:

> The primary mechanism by which diet reduces subjective pain may be a result of normalization of the fatty acid profile and reduction in exposure to inflammatory protein precursors. Western diets are high in arachidonic acid, which are modified into proinflammatory prostaglandins and leukotrienes. Nonsteroidal anti-inflammatory drugs work to reduce pain by limiting the metabolism of arachidonic acid. Arachidonic acid is found in animal foods and some vegetable oils. Therefore, the adoption of a WFPB will dramatically reduce the availability of precursors necessary to produce painful prostaglandins.[1970]

To treat osteoarthritis, some patients turn to dietary supplements, including glucosamine and chondroitin, which are described by the National Institutes of Health National Center for Complementary and Integrative Health (NCCIH) as "structural components of cartilage, the tissue that cushions the joints."[1971] While these components are found naturally in the body, they are also available as over-the-counter dietary supplements.[1972] Glucosamine in particular has received attention as being able to reduce the symptoms of osteoarthritis of the knee;[1973] however, most major studies of the supplement's effects (on knees as well as other joints) have had conflicting results.[1974,1975,1976,1977,1978,1979,1980,1981,1982] In 2008, the National Institutes of Health (NIH) conducted a large-scale, multicenter clinical trial published in *Journal of Pain & Palliative Care Pharmacotherapy* testing the efficacy of glucosamine and chondroitin supplements in treating knee osteoarthritis and found:

> For a subset of participants with moderate-to-severe pain, glucosamine combined with chondroitin sulfate provided statistically significant pain relief compared with placebo—about 79 percent had a 20 percent or greater reduction in pain versus about 54 percent for placebo... For participants in the mild pain subset, glucosamine and chondroitin sulfate together or alone did not provide statistically significant pain relief.[1983]

The NCCIH notes that some European studies of glucosamine have reported positive effects of the supplement on knee pain and function.[1984]

Gout

Osteoarthritis can predispose the depositing of monosodium urate crystals into joint sites, leading to gout, which is another type of arthritis.[1985,1986] Gout is characterized by sudden and severe pain localized to one or more joints, but is most commonly found in the big toe.[1987,1988] Consumption of high-fructose corn syrup (which is prominent in Western diets) can lead to a buildup of uric acid, which causes gout.[1989] Other dietary risk factors for gout include a high consumption of meat and alcohol.[1990,1991,1992] The management of gout focuses primarily on medical treatment, but diet can also play a significant role.[1993] The body makes uric acid when it breaks down purines; therefore the intake of foods high in purine, such as meat, beer, bread, and certain legumes, might increase the frequency of gout flares.[1994] Research has also shown that increased intake of fruits, especially cherries, can help prevent gout flares.[1995] Clerodendranthus spicatus, often referred to as "Kidney tea," an herbal remedy used in Traditional Chinese Medicine, may have the potential to reduce pain and swelling when taken during a gout flare-up.[1996]

Ankylosing spondylitis

Ankylosing spondylitis is an arthritis of the spine that can cause back pain and stiffness,[1997] and for some people gastrointestinal problems.[1998,1999,2000,2001] A 2010 study of 165 adults in Sweden with ankylosing spondylitis, published in *Clinical Rheumatology*, found that gastrointestinal pain was more prevalent in those who reported high consumption of vegetables and less prevalent among those who consumed milk and soured milk.[2002] The authors note that certain vegetables are high in a collection of short-chain carbohydrates that are not properly absorbed in the gut and hypothesize that "an inappropriate absorption may allow these foodstuffs to reach the distal ileum and colon where they affect the bowel flora, thereby creating the symptoms of an irritable bowel."[2003] Overall, there are not enough studies investigating the relationship between diet and dietary supplements and ankylosing spondylitis.[2004,2005] Despite the lack of published research, dietary modifications and vitamin supplementation are still common among ankylosing spondylitis patients.[2006,2007]

Psoriatic Arthritis

Psoriatic arthritis is a chronic type of inflammatory arthritis that is linked with psoriasis, an autoimmune condition that causes red and scaly patches on the skin.[2008] Dietary interventions have been found to be an effective supplemental therapy to reduce the severity of psoriatic arthritis.[2009] A 2018 study published in *JAMA Dermatology* of 158,361 psoriatic arthritis patients suggested that adherence to the Mediterranean diet might result in lower disease activity.[2010] In a 2020 study in the *Journal of the American Academy of Dermatology*, researchers wrote, "[p]atients often ask about the potential for dietary factors, and gluten intake in particular, to modify risk of other inflammatory skin diseases, including psoriasis and atopic dermatitis."[2011] However, adopting a gluten-free diet has yet to be shown effective at treating psoriatic arthritis.[2012,2013,2014]

Arthritis, Rheumatoid

Rheumatoid arthritis is an autoimmune disease in which the immune system attacks healthy cells, causing painful inflammation.[2015,2016] It is characterized by pain, stiffness, and swelling in the joints (such as the wrist, hands, feet, spine, knees, and jaw), which can flare up and worsen from time to time.[2017,2018] According to the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), risk factors for rheumatoid arthritis include advanced age, smoking, obesity, and gum disease.[2019]

Research has demonstrated that eating higher amounts of fish and/or taking fish oil is associated with lower rates of pain and other negative symptoms of rheumatoid arthritis.[2020,2021,2022,2023] The Mediterranean diet has been shown to help patients manage rheumatoid pain.[2024] A 2018 study in *Clinical Nutrition* showed that monounsaturated fatty acids (found in olive oil and avocado oil) might be the key nutrients that suppress disease activity.[2025] Some research has also found that low-fat plant-based diets reduce rheumatoid arthritis symptoms by eliminating many of the most common triggers.[2026,2027] In a 2020 journal article in *BMC Rheumatology*, researchers advised that dietary intervention should not be the sole treatment plan for rheumatoid arthritis, but also noted that dietary choices play a role in disease management, writing, "Adherence to the Mediterranean diet is generally recommended, with a plant-based regimen abundant in wholegrains, legumes, five or more fruit and vegetables per day, preferably seasonal."[2028] Anti-inflammatory foods have potential in the treatment of rheumatoid arthritis.[2029,2030,2031,2032]

A 2021 review in the journal *Clinical Nutrition* outlined the ideal "food pyramid" for a person living with rheumatoid arthritis, which included the following:

> [C]arbohydrates should be consumed every day (3 portions of whole grains, preferably gluten free), together with fruits and vegetables (5 portions; among which fruit, berries and citrus fruit are to be preferred, and among the vegetables, green leafy ones.), light yogurt (125 ml), skim milk (200 ml), 1 glass (125 ml) of wine and extra virgin olive oil; weekly, fish (3 portions), white meat (3 portions), legumes (2 portions) eggs (2 portions), seasoned cheeses (2 portions), and red or processed meats (once a week).[2033]

While food certainly has an impact, some researchers argue that more studies and observation are needed before a concrete dietary recommendation can be made about the relationship between food and rheumatoid arthritis.[2034,2035,2036]

Juvenile Idiopathic Arthritis

Juvenile idiopathic arthritis (JIA) is another type of autoimmune arthritis that begins in childhood.[2037] The word "idiopathic," which means unknown, refers to researchers' lack of understanding about what causes JIA.[2038] Like rheumatoid arthritis, JIA is a form of inflammatory arthritis; however, according to the Arthritis Foundation, "it is not a kid version of the adult disease."[2039] About 5 percent of children with JIA have a subtype of the disease whose observable physical and biochemical characteristics resemble those of adult rheumatoid arthritis.[2040]
While research has not supported a standard diet for the treatment of JIA, parents and families of people with JIA often consider diet a factor contributing to disease activity.[2041,2042,2043,2044] In a 2014 survey of 50 Finnish children with JIA published in *BMC Complementary Medicine and Therapies*, 28 percent of respondents reported using dietary restrictions to help manage their condition, although the effects of these dietary changes on the children's disease activity are unclear.[2045]

Autism

Autism spectrum disorder (ASD) is a group of neurodevelopmental disorders characterized by difficulty communicating and socializing with others, as well as repetitive behaviors and narrow interests.[2046,2047] An estimated 1 in 110 children have ASD, presenting a range of symptoms varying from mild to severe.[2048] It is four times more common in boys than girls.[2049] The impact of the disorder on children as they age varies with the severity of their case, the symptoms they present, and the promptness of their diagnosis.[2050] Although the cause of ASD remains unknown, early treatment is associated with milder symptoms long-term and overall improvements in quality of life.[2051]

Given that few treatments have shown to be effective at mitigating the core symptoms of autism, many patients and their families seek alternative and food-based medicine.[2052] Around 25 percent of people with ASD follow a specialized diet or use dietary supplements to manage their condition.[2053] Gluten-free (aims to eliminate wheat, barley, and rye) and casein-free (aims to eliminate milk and dairy products) diets are most common, although clinical studies have been unable to provide sufficient evidence to support the diet as a treatment for ASD.[2054,2055,2056,2057,2058,2059] Due to the lack of sufficient clinical studies about these diets, some researchers have explicitly advised against it; in the *Journal of Child Neurology* in 2014, researchers wrote:

> [T]he evidence to support gluten-free, casein-free diets is limited and weak, such dietary restrictions being associated with social rejection, stigmatization, deficits in socialization and integration, and a misuse of resources, as well as potential adverse biomedical effects. Hence, we advise against resorting to elimination diets in an attempt to treat autism spectrum disorders. Specifically, until there is conclusive evidence of the benefits of gluten-free, casein-free diets in autism spectrum disorders, they should only be introduced after the diagnosis of an intolerance or allergy to allergens in the foods that would be eliminated in such a diet.[2060]

Limited research has been conducted to evaluate the impact of a ketogenic diet in the management and treatment of symptoms for ASD.[2061,2062,2063,2064] Studies in which mice were fed a ketogenic diet have shown promise in reducing seizures and anxiety, but initial research has yet to rule out other variables such as lower caloric intake resulting from the dietary change as the cause of the reduction in core symptoms.[2065,2066,2067,2068] This reduction in anxiety could potentially play a role in normalizing social interactions, which many individuals with ASD struggle with.[2069]

Existing studies of the impact of a ketogenic diet on humans with ASD have used small sample sizes, but have demonstrated behavioral improvements in some children with ASD.[2070,2071] The Childhood Autism Rating scale is a diagnostic tool used by trained clinicians to rate items indicative of ASD after direct observation.[2072] In a 2018 study appearing in the journal *Physiology & Behavior* monitoring the impact of a modified ketogenic and gluten-free diet on children with autism aged 2 to 17 years, researchers found that "50 percent of subjects showed improvement on [the Childhood Autism Rating Scale, 2nd Edition] scores in the areas of imitation, body use, and fear or nervousness."[2073] The researchers conclude that the ketogenic diet warrants further investigation with larger sample sizes.[2074]

Some clinical evidence has shown that children with autism may have abnormally low levels of fatty acids relative to non-autistic children,[2075,2076,2077,2078] and these findings have spurred research into omega-3 and omega-6 supplements as treatments.[2079,2080,2081] However, these studies have not produced sufficient evidence associating fatty

acid supplements with improved ASD symptoms.[2082,2083,2084,2085,2086] Another dietary supplement, sulforaphane (a phytochemical derived from broccoli sprouts), might have a positive impact on irritability among those with ASD.[2087,2088] Clinical trials investigating other potential applications of sulforaphane in the treatment of ASD are currently inconclusive but remain ongoing.[2089,2090,2091,2092,2093]

Dietary supplements, such as omega-3 fatty acids, zinc, melatonin, and others, have also received significant attention as possible treatments for ASD symptoms.[2094,2095,2096,2097,2098,2099,2100] Some clinical studies have resulted in minor behavioral and functional improvements for participants receiving these supplements, but researchers acknowledge that not all people with ASD will respond similarly to dietary supplements.[2101,2102,2103,2104,2105,2106,2107]

Other researchers have argued that dietary supplementation is unnecessary for children with ASD because it might lead to excessive intake of certain nutrients, particularly vitamin A, folate and zinc.[2108] This can have negative outcomes; for example, excessive intake of vitamin A can lead to side effects such as nausea, headache, fatigue, loss of appetite, psychiatric changes, osteoporosis, and irritability.[2109]

Studies analyzing the impacts of herbs used in Traditional Chinese Medicine on the core symptoms of autism have found mixed results.[2110,2111,2112,2113] One very small study (n = 3) conducted in 2009 appearing in the *Journal of Dietary Supplements* measured the effects of *Panax ginseng* on children with autism and revealed very slight improvement in measures of irritability, hyperactivity, inadequate eye contact, and inappropriate speech.[2114] However, the author of the study concluded: “Since there does not seem to be any significant improvement caused by *Panax ginseng*, its effect as an add-on therapy... requires further investigation. Before knowing its efficacy for adults, *Panax ginseng* should not be recommended for treating children suffering from autism.” A 2012 randomized controlled trial in *Child Psychiatry & Human Development* testing the effects of *Ginkgo biloba* on children with autism also did not result in significant improvement in autism symptoms.[2115] However, one 2012 study published in *Evidence-Based Complementary and Alternative Medicine* showed that a Traditional Chinese Medicine dietary intervention that emphasized grains, vegetables, fruits, beans, mushrooms, nuts, and root vegetables (while reducing ginger, garlic, green onion, spicy foods, eggs, meat, and fish) resulted in improved executive function among children with ASD.[2116]

Children on the autism spectrum are more likely to exhibit nutritional deficiencies than children who do not have ASD.[2117] Selective eating, tantrums, inattention at mealtime, and aversion to new foods are all commonly reported in autistic children.[2118,2119] These restrictive feeding behaviors are thought to contribute to deficiencies in Vitamin A, Vitamin B6, Vitamin B12, Vitamin C, Vitamin D, calcium, zinc, and fatty acids in autistic youth.[2120,2121,2122,2123,2124,2125,2126] A 2011 study appearing in *Nutrition & Metabolism* has suggested that the levels of necessary vitamins, minerals, and plasma amino acids in children with ASD are inversely correlated with the severity of their symptoms, with those managing more serious cases exhibiting more significant malnutrition.[2127] Malnutrition negatively affects cognitive and social development, making it imperative that pediatricians and families find ways to improve the nutrient intake of children with ASD.[2128] Furthermore, malnutrition and vitamin deficiencies among children with ASD has been linked to scurvy, bone-thinning, and vision loss.[2129,2130,2131,2132,2133,2134,2135]

Food selectivity also leads to an increased prevalence of diet-related diseases among autistic children[2136] who tend to restrict their consumption to foods that are high in calories and refined carbohydrates that provide little

nutritional diversity and lead to weight gain and obesity.[2137,2138,2139,2140,2141,2142] As a result, dietary evaluations and feeding interventions to mitigate food selectivity are recommended for all children diagnosed with ASD in order to improve the variety of foods and nutrients consumed among these children.[2143,2144,2145,2146]

Children with ASD frequently exhibit gastrointestinal problems, including constipation, gas, and diarrhea.[2147,2148] Research has shown evidence that children with ASD may have alterations of gut microbiota and may create gastrointestinal issues.[2149,2150,2151] Ongoing studies of the gut-brain axis—the physiological connections between the microbiome in the gut and the brain—have begun to indicate a possible link between the makeup of an individual's gut flora and the severity of their ASD symptoms.[2152,2153,2154,2155,2156] If such a connection is firmly established, there may, in fact, be a role for food-based interventions that alter patients' gut microbiomes as a means of managing and treating ASD.[2157,2158]

Cancer

Cancer is an umbrella term for more than a hundred diseases caused by abnormal cell growth in any part of the body.[2159] The National Institutes of Health National Cancer Institute (NCI) emphasizes, "it's important to know there isn't just one food or special diet that has proved to control cancer."[2160]

The NCI recommends that all cancer patients maintain "healthy eating habits" and incorporate all their needed nutrients into their diets, which can be difficult for patients experiencing loss of appetite, changes in taste, trouble swallowing, and other side effects of cancer treatment.[2161] To help patients manage their diet throughout cancer treatment, the NCI compiled a list of dietary changes that can be made to treat various side effects and symptoms of cancer and cancer treatment.[2162] For example, cancer patients with changes to their sense of taste are advised to avoid red meat and try high-protein vegetarian recipes instead.[2163]

Fruit and vegetable intake is frequently studied for its impact on the prevention, treatment, and recurrence rate of various cancers.[2164,2165,2166,2167,2168,2169,2170] One 2020 analysis of 150 colorectal cancer survivors appearing in the *British Journal of Nutrition* showed that "[a] higher intake of fruit and vegetables was associated with significantly better physical functioning."[2171] Furthermore, in a 2020 review published in the journal *Advances in Nutrition*, researchers wrote:

> …the consumption of ~300 g/d of vegetables by head and neck cancer patients and ~300 g/d of vegetables and ~300 g/d fruit separately by ovarian cancer patients decreased overall mortality. Moreover, it is important to bear in mind that none of the studies have detected a harmful relation with the consumption of fruit and vegetables in cancer patients.[2172]

In a study of 8,927 women with breast cancer appearing in *Cancer Research* in 2020, researchers wrote:

> …we observed better overall survival after breast cancer diagnosis among women with higher vegetable consumption; specifically, green leafy vegetables as well as cruciferous vegetables, fruits and vegetables high in vitamin C, and vegetables rich in β-carotene. Although eating higher amounts of vegetables may not affect breast cancer-specific mortality, high intake of vegetables and some fruits may improve overall survival. High post-diagnostic fruit juice intake may also be associated with increased risk of death due to breast cancer and all causes, and this finding needs further evaluation.[2173]

Additional research supports the role of individualized nutrition education in cancer care. One 2018 study published in *Annals of Behavioral Medicine* demonstrated that participation in a 12-week exercise and dietary intervention consisting of individualized nutritional counseling with an emphasis on adopting a plant-based diet resulted in "significant, clinically meaningful improvements in mobility performance, muscular strength, and body composition" among prostate cancer patients.[2174] Another 2019 study appearing in *Nutrition and Cancer* showed that individualized nutritional education and dietary intervention led to a reduction in negative gastrointestinal side effects from chemotherapy.[2175] Some of the recommendations provided to participants included eating frequent small meals and avoiding spicy, fried, sugary or very aromatic foods.[2176]

Research has also suggested that the ketogenic diet might be an effective dietary intervention for cancer patients to starve cancerous cells of energy from carbohydrates while normal cells adapt to use ketone bodies (compounds produced during the metabolism of fats) to survive.[2177]

Sugar consumption has been connected to cancer occurrence and recurrence in numerous studies,[2178,2179,2180,] although findings are inconsistent.[2181,2182] In one long-term study appearing in *Cancer Prevention Research* of more than 3,000 adults aged 26-84 years, study participants were asked to fill out food frequency questionnaires from 1991 until 1995, and were followed up with until 2013 regarding cancer incidence as confirmed from pathology reports in the patient's medical record.[2183] The researchers concluded:

> Sugary foods were not associated with the risk of any cancer. However, in exploratory stratified analyses, total consumption of sugary beverages was associated with 59 percent higher risk of adiposity-related cancers [cancers related to higher body weight, such as breast, prostate, and colorectal] in participants with excessive central adiposity [excess body fat resulting in a weight circumference greater than 40 inches for men and 35 inches for women].[2184]

This is consistent with other studies of the relationship between sugar-sweetened beverage consumption and cancer occurrence.[2185,2186] However, researcher Mingyang Song, ScD, Assistant Professor of Clinical Epidemiology and Nutrition at Harvard School of Public Health, noted the need for additional research into the sugar-cancer connection in the *American Journal of Clinical Nutrition* in 2020. He wrote:

> Like many questions in nutrition, strong biological plausibility does not necessarily lead to positive findings in epidemiology. This is particularly true when it comes to the sugar–cancer relation. The reasons are multifaceted and related to the challenges of accurate dietary assessment over a long period of time, adequate control for confounding by other dietary/lifestyle exposures, identification of the most relevant time window for exposure assessment, consideration of potential effect modifications by population characteristics, and heterogeneity between and within cancer types.[2187]

In conjunction with medical treatment, a tailored nutritious diet can help to counter side effects, repair damaged tissue, and maintain energy levels.[2188] The American Cancer Society recommends that patients going through treatment consume more calories and

protein, and snack often.[2189] This can include a variety of protein-rich snacks such as yogurt, cereal and milk, and cheese and crackers.[2190] Different cancer treatments can have very different side effects; however, loss of appetite is one of the most common side effects of cancer treatment (including chemotherapy, radiation therapy, and surgery) and is the most common cause of malnutrition in cancer patients.[2191] Furthermore, chemotherapy treatment often causes alterations in taste and smell, which can lead to changes in food behavior.[2192] A systematic review published in *Supportive Care Cancer* in 2020 found that the use of oral nutrition supplements and dietary counseling and increases in EPA (a fatty acid) from fish oil supplementation improved the appetite and nutrition outcomes of patients with cancer undergoing cancer treatments.[2193]

Cancer treatment plans are highly individualized to meet the needs of patients, so food as medicine interventions for cancer patients should be equally tailored to specific needs and conditions.[2194,2195,2196] Researchers Itziar Tueros, PhD and Matxalen Uriarte, PhD wrote about the need to accommodate changing food preferences among cancer patients in the *Journal of the Science of Food and Agriculture* in 2018:

> Taking into account that reduced food enjoyment during cancer treatment can give rise to negative physical, emotional and social consequences, taste and smell alterations, food preferences and specific nutritional requirements should be combined and considered by the food industry when designing innovative formulae for cancer patients. The development of new food products or the revision of existing ones is necessary to prevent or tackle malnutrition, being the main challenge in oncological nutrition, as it is a determinant factor for adverse outcomes, including increased morbidity and mortality, and decreased quality of life.[2197]

An example of a highly individualized dietary intervention for cancer treatment can be found at NYU Langone's Perlmutter Cancer Center in New York City.[2198] The hospital launched a program in 2016 to provide patients with individualized home-delivered customized meals that take into account the reasons for their loss of appetite (which might include nausea, depression, or difficulty swallowing).[2199] According to the NCI, many cancer patients might seek out complementary medicines, including dietary intervention, to pursue alongside regular treatment for a variety of reasons, including:

- Help coping with the side effects of cancer treatments, such as nausea, pain, and fatigue
- Comforting themselves and ease the worries of cancer treatment and related stress
- Feeling that they are doing something to help with their own care
- Trying to treat or cure their cancer[2200]

However, the NCI warns that patients and caregivers should be aware of any potentially negative interactions between cancer treatment drugs and the foods patients eat. For example, St. John's wort, which is sometimes taken by patients as a complementary treatment for depression,[2201] has been shown to reduce the efficacy of certain cancer drugs such as imatinib[2202] and docetaxel.[2203]

Chronic Kidney Disease

Chronic kidney disease (CKD) is the gradual loss of kidney function due to damage, usually from high blood pressure and high blood sugar.[2204,2205] Because kidneys act as filters for wastes, kidney damage can result in a buildup of wastes in the body.[2206] The kidneys balance out nutrients in the body, such as sodium, phosphorus, potassium, so people suffering from CKD have to closely monitor their intake of these nutrients.[2207,2208] The CDC estimates that more than 1 in 7 US adults have CKD, however, 90 percent of people living with the disease do not know they have it.[2209] Certain diet-related diseases, including diabetes and hypertension, are risk factors for CKD.[2210] Furthermore, high intake of meats and refined carbohydrates increases individuals' risk of CKD.[2211,2212,2213,2214]

For those living with CKD, low-protein, and vegetarian diets have been shown to delay progression of the disease and the onset of renal failure.[2215,2216] Since plant-based foods tend to be higher in fiber than meat, higher intake of vegetables and grains can result in more frequent bowel movements and, therefore, less retention of uremic toxins in the blood.[2217] However, patients with advanced CKD should attempt to limit their intake of potassium-rich fruits and vegetables, such as bananas and carrots, because potassium has been associated with faster progression of the disease.[2218]

The National Institutes of Health National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) recommends a five-step system for CKD patients interested in changing what they eat to manage their condition.[2219] The five steps are:

- "Choose and prepare foods with less salt and sodium." To do this, the NIDDK advises patients to cook from scratch more, and use spices and herbs to flavor food rather than salt.
- "Eat the right amount and the right types of protein." Protein-rich foods should be eaten in small portions so that the kidneys do not have to filter too much waste produced by the body's use of protein.
- "Choose foods that are healthy for your heart." Cooking with olive oil instead of butter, trimming fat and skin from meat, and avoiding deep-fried foods are some ways to ensure food is heart-healthy.
- "Choose foods and drinks with less phosphorus." Fresh fruits, vegetables, breads, pasta, and rice are examples of foods low in phosphorus.
- "Choose foods with the right amount of potassium." People with CKD need to make sure their blood potassium levels do not build up. Apples and peaches are among the fruits low in potassium, and white breads and pastas have less potassium than their whole-wheat counterparts.[2220]

Beyond the aforementioned dietary changes that people living with CKD can make, researchers have found that the incorporation of bioactive nutrients, such as microbiota that live in the gut, into the diet can help prevent and treat CKD.[2221] Gut microbes play

an important role in the body's metabolism and immune responses, and diet directly influences the microbial microbiome of the gut.[2222,2223,2224,2225,2226]

Dietary interventions that manage the microbiome can also help control the production and absorption of some uremic toxins, which are toxic compounds which cannot be eliminated from the body and accumulate in the bloodstream.[2227] Research into the role of diet in the treatment of CKD has been applied to some existing food as medicine interventions that target patients with the disease.[2228] Many medically-tailored meal programs, including Community Servings in Boston,[2229] Mama's Kitchen in San Diego[2230] and God's Love We Deliver in New York City,[2231] serve nutritious and appropriate food to patients with CKD that have been shown to improve health outcomes by slowing disease progression, especially for those patients who are also experiencing food insecurity.[2232] See more on medically tailored meals in Part 3 .

Cirrhosis and Ascites

Cirrhosis of the liver describes scarring of the liver caused by various diseases, including hepatitis and excessive alcohol consumption. Increased scar tissue makes it more difficult for the liver to function properly, which can be life-threatening.[2233] Cirrhosis can cause ascites, a condition that occurs when fluid collects in the abdomen, causing extreme pain and difficulty breathing if the fluid moves close to the lungs.[2234]

Malnutrition is a common complication associated with cirrhosis.[2235,2236,2237] According to a 2019 review published in *Current Gastroenterology Reports*, "Nutritional status is an important predictor of morbidity and mortality in cirrhosis, and it has important implications in selection for liver transplant as poorer nutritional status correlates with higher postoperative complications."[2238] Nutritional intervention is a standard part of the treatment plan for a patient with cirrhosis or ascites.[2239] Early nutrition plans for people with either of these conditions usually include a reduction in sodium intake, however, researchers have found that a reduced-sodium diet alone has minimal results.[2240] Sodium restriction in conjunction with protein supplementation might have a stronger effect, but clinical research is still scarce.[2241]

Researchers have found that nutritional status correlates strongly with a patient's prognosis when diagnosed with ascites caused by cirrhosis, and nutritional support (such as a medically tailored evening snack) can contribute to improved survival of the disease.[2242] Many researchers agree that nutritional intervention should be implemented early in a patient's treatment.[2243,2244,2245,2246] Furthermore, "dietary management of cirrhosis is not a one-size fits all approach," wrote reviewers in the *Journal of Clinical Gastroenterology* in 2018, and should be tailored to individual needs.[2247]

Diabetes

Diabetes is a disease that compromises the body's ability to produce or respond to the hormone insulin, resulting in abnormal metabolism of carbohydrates and elevated levels of glucose in the blood and urine.[2248,2249] Type 1 diabetes (previously called insulin-dependent or juvenile diabetes) refers to a condition where the pancreas either doesn't produce any insulin or doesn't produce sufficient insulin and requires daily administration of insulin.[2250] Type 2 diabetes is the most common form of diabetes and results from the body's ineffective use of insulin.[2251] Symptoms of diabetes can include: excessive thirst and/or hunger, frequent urination, unexplained weight loss, fainting, numbness in hands or feet, slow wound healing, and blurred vision.[2252,2253] If left untreated, or not treated properly, diabetes can lead to complications including heart attack, stroke, and permanent damage to the kidneys, nerves, and eyes.[2254,2255]

Diabetes affects 34.2 million people in the US and 422 million worldwide.[2256,2257] It is estimated that 88 million American adults have prediabetes, which is categorized by slightly higher than normal blood sugar levels indicative of increased risk of type 2 diabetes.[2258,2259] There is strong evidence that various health and behavioral factors put individuals at increased risk for diabetes and related complications including obesity and overweight, high blood pressure, high cholesterol, physical inactivity and tobacco use.[2260]

Among US adults aged 18 years or older diagnosed with diabetes, 89 percent were overweight or had obesity, defined as a body mass index (BMI) of 25 kg/m2 or higher.[2261] As overweight and obesity is the most strongly associated risk factor connected with developing Type 2 diabetes and related complications, there has been great interest in the scientific and lay communities regarding the impact of diet on both preventing and treating diabetes.[2262] Change in diet, along with exercise and medication, are standard recommendations as part of treatment plans for individuals with diabetes.[2263]

Research on a variety of dietary patterns have shown positive results in the treatment and management of diabetes.[2264,2265] The American Diabetes Association (ADA) 2019 guidelines of care state that nutrition and diet should be individually tailored to meet the goals of blood glucose and weight management of a patient.[2266] The ADA states that individualized medical nutrition therapy (MNT) is a core component of diabetes management:

> For many individuals with diabetes, the most challenging part of the treatment plan is determining what to eat and following a meal plan. Each person with diabetes should be actively engaged in developing an individualized eating plan. All individuals with diabetes should be offered a referral for individualized MNT provided by a RD who is knowledgeable and skilled in providing diabetes-specific MNT.[2267]

Individual nutrition therapy is recommended for all people with type 1 and type 2 diabetes and has shown to be effective for improving glycemic control (target blood glucose levels) and various markers of cardiovascular and hypertension risk.[2268]

Overall, research has shown that diets rich in fruits and vegetables, whole grains, nuts and legumes and lower in red and processed meats, refined grains, and sugar-sweetened beverages are consistently associated with a decreased risk of diabetes[2269,2270,2271,2272] as well as maintenance of target blood glucose levels for people living with type 2 diabetes.[2273,2274,2275] However, clinical guidelines suggests that there is not an ideal macronutrient profile (carbohydrates, protein, and fat) for all people with diabetes.[2276]

There is extensive evidence to suggest that the Mediterranean diet is associated with improved outcomes of glycemic control, body weight, and cardiovascular risk factors in patients with type 2 diabetes.[2277,2278,2279] A meta-analysis published in the *European Journal of Clinical Nutrition* in 2015 included data from nine randomized controlled trials comparing the effects of the Mediterranean diet with control diets in patients with type 2 diabetes.[2280] The study concluded that adherence to a Mediterranean diet seems to have a protective role in glycemic control as reflected by reduced HbA1c (average blood glucose levels over the past three months) and lower fasting levels in addition to decreased insulin resistance and mortality.[2281]

A systematic review of eight meta-analyses and five randomized controlled trials published in *BMJ Open* in 2015 compared the Mediterranean diet with a control diet in the treatment of type 2 diabetes.[2282] The study concluded that "The Mediterranean diet was associated with better glycemic control and cardiovascular risk factors than control diets, including a lower fat diet, suggesting that it is suitable for the overall management of type 2 diabetes."[2283]

Research has also demonstrated that a vegetarian diet may also improve glycemic control in patients with diabetes.[2284,2285] A 2019 systematic review and meta-analysis of nine randomized controlled trials published in *Clinical Nutrition* showed that vegetarian dietary patterns improved glycemic control and other established cardiometabolic risk factors in individuals with diabetes over a median follow-up of 12 weeks.[2286] While research suggests the potential benefits of a vegetarian diet, further information is needed to explore the long term effects of this dietary approach on the management of diabetes.[2287]

Fiber is recommended as part of a healthy diet for the management of type 2 diabetes.[2288] Fiber is able to slow down blood sugar spikes after meals[2289,2290] and reduce HbA1c and plasma fasting glucose for people with diabetes.[2291,2292,2293,2294] A systematic review and meta-analysis published in *PLoS Med* in 2020 examined the effects of a higher fiber intake in adults with prediabetes, type 1 diabetes, and type 2 diabetes and found that higher-fiber diets resulted in improvements in measures of glycemic control, blood lipids, body weight, and inflammation, as well as a reduction in premature mortality.[2295] The study findings concluded with the recommendation that increasing daily fiber intake by 15 g or to 35 g might be a reasonable target that would be expected to reduce risk of premature mortality in adults with diabetes.[2296] This recommendation is consistent with 2020-2025 Dietary Guidelines for Americans, which recommends that adults eat 22 to 34 grams of fiber each day, the specific amount varying depending on age and sex.[2297]

Other diets that have been studied for their effect on diabetes management include low-carbohydrate, low-glycemic index (GI), and high-protein.[2298] In low-carbohydrate diets, carbohydrates can be reduced to different levels; according to a 2011 review appearing in *Nutrition in Clinical Practice*, the typical definitions for types of low-carbohydrate diets are:

1. Reduced-carbohydrate diet: >130 g of carbohydrate per day, up to 45% of total calories

2. LC diet: 30-130 g of carbohydrate per day

3. Very low-carbohydrate ketogenic (VLCK) diet: <30 g of carbohydrate per day; will usually permit ketosis to occur.[2299]

Multiple studies, including randomized controlled trials, have shown that reducing carbohydrate intake might help patients manage their diabetes.[2300,2301,2302,2303,2304] Low-GI diets include low-glycemic foods (such as oats or muesli), with white bread as the reference point for the highest glycemic food.[2305,2306] These diets might help people with diabetes manage their body weight.[2307,2308,2309] In addition, high protein diets have been used to manage body weight and glycemic control among diabetic patients.[2310,2311,2312] In one 2021 study appearing in the *European Journal of Nutrition*, participants who followed a diet with meals provided that consisted of 30 percent of energy from protein (as opposed to the control of 15 percent) saw improvements in body weight, liver fat content, and HbA1c concentrations throughout the 36-week intervention.[2313]

Research has also explored the potential benefits of components of specific foods in the management of diabetes. For example, researchers have demonstrated that omega-3s from foods such as walnuts may help to reduce overall inflammation and oxidation as well as improving vascular function in patients with diabetes.[2314,2315,2316,2317] Studies also suggest that probiotics may have a role in diabetes management by reducing autoimmune responses, decreasing inflammatory reactions and increasing insulin sensitivity.[2318,2319,2320] A systematic review and meta-analysis published in *Nutrition & Diabetes* in 2017 stated that olive oil could be beneficial in the treatment of diabetes and reported that olive oil supplementation resulted in significantly more pronounced reduction in HbA1c and fasting plasma glucose as compared with the control groups.[2321]

Ensuring that dietary interventions for diabetes patients are appropriate for their cultural and religious needs is important for health care providers and dietitians designing these programs to keep in mind.[2322,2323,2324,2325,2326,2327,2328,2329] In a 2020 article appearing in the journal *Health Expectations*, dietitians reported feeling insecure about providing nutritional advice to immigrant patients, citing language barriers and differences in food habits as being major obstacles to providing adequate care.[2330] Obstacles such as these can lead to a lack of adherence to doctor's recommendations; in a 2019 study appearing in *Public Health Nutrition* of Mayan communities in Mexico, researchers wrote, "Non-adherence [to physician instructions] was influenced by lack of patient–provider shared knowledge and medical recommendations misaligned with local culture."[2331]

"Clinicians must develop self-management guidance within the sociocultural context of the patient if diabetes outcomes are to improve and be sustained," write researchers in the *Journal of Clinical Nursing* in 2016.[2332] Several dietary patterns have demonstrated benefits for diabetes management, including low-carbohydrate, low-GI, Mediterranean, and high-protein diets,[2333] and should be selected based on individuals personal and cultural food preferences and metabolic goals.[2334] However, a better understanding of food habits among cultures around the world is needed in order for physicians, dietitians, and other health care providers to make appropriate and effective recommendations; according to researchers writing in *The Lancet* in 2014, "High quality, large sample size intervention and observational studies and region-specific recommendations are lacking from diverse populations and cultures."[2335]

Food insecure adults are at a higher risk for diabetes and experience increased challenges with diabetes management.[2336,2337,2338] Often, the most affordable foods are calorie dense and high in sugar, sodium, and fat, which contribute to disease progression and activity.[2339,2340] Additionally, food insecurity may alter food intake or establish binge-fast cycles based on food access and availability.[2341] Periods of food scarcity may be followed by periods of overconsumption and avoidance of food waste that can lead to hyperglycemia.[2342] Diabetes is also associated with a higher per-capita out-of-pocket health care expenditure than any other disease (including heart disease and cancer), which leads patients to purchasing cheap, processed foods high in sugar, sodium, and fat.[2343,2344] Medically tailored meal programs[2345] and food prescription programs[2346] are two common Food as Medicine interventions that often aim to improve food access in diabetic populations. To learn more about programmatic interventions to address diabetes and other diet-related chronic diseases, see Part 3.

Inflammatory Bowel Diseases

More than 1.8 million people in the United States have an inflammatory bowel disease (IBD), which refers to a group of chronic autoimmune inflammatory diseases of the gastrointestinal (GI) tract.[2347] Clinical symptoms of IBDs include constipation, diarrhea, abdominal cramps, blood and mucus in the stool, and bowel obstruction.[2348,2349,2350] Ulcerative colitis (UC), a chronic disease in which abnormal reactions of the immune system cause inflammation and ulcers on the inner lining of the large intestine, and Crohn's disease (CD), a chronic disease that causes inflammation and irritation of the digestive tract, are the most common IBDs.[2351] Individuals with IBD go through periods of active disease that, if left untreated, can progress to the point of requiring hospitalization and surgery.[2352,2353] Half of CD patients require surgical intervention in the ten years following their diagnosis and over a third need more than one procedure.[2354] Long term, persistent inflammatory responses, including IBD, pose significant risk factors for chronic inflammatory conditions, cancer, and infectious disease.[2355]

According to the National Institutes of Health National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), the exact cause of IBDs such as UC and CD is still unclear.[2356,2357] However, much research has been conducted investigating the potential role individual diet plays in the development of IBDs.[2358,2359] Several studies conducted between 2005 and 2011 determined that the omega-6 polyunsaturated fats found in red meat, cooking oils, and margarine increased the risk of developing IBD.[2360,2361,2362,2363] Furthermore, a 26-year longitudinal study of more than 100,000 female nurses, appearing in the journal *Gut* in 2014, concluded that "high intake of trans-unsaturated fats may be associated with an increased risk of UC."[2364]

Additional research has suggested that IBD may be tied to the ratio of omega-3 versus omega-6 fatty acids an individual consumes rather than overall intake.[2365] A 2019 review published in *International Journal of Molecular Science* found omega-3 fats "may regulate and attenuate the inflammatory processes and lead to remission of IBD and, thus, could be considered as a new complementary approach to the treatment of these inflammatory conditions."[2366]

Some research has explored potential connections between the consumption of animal products (including dairy and animal proteins) and the development of IBD.[2367,2368,2369,] In a 2010 study of more than 60,000 middle-aged French women, published in *The American Journal of Gastroenterology*, researchers found:

> …high protein intake was associated with an increased risk of IBD. The positive association between high protein intake and IBD risk was restricted to animal protein intake. Among animal protein sources, both fish and meat were associated with risk, whereas egg and dairy products were not, potentially because of insufficient power.[2370]

However, more research is required before a connection between protein or dairy intake and the development of IBD can be established.[2371,2372,2373,2374,2375]

Consumption of animal products (processed meat and red meat in particular) has also been studied for its potential effect on IBD symptoms.[2376,2377,2378,2379] One 2020 randomized controlled trial appearing in the journal *Gastroenterology* showed that a diet low in red and processed meats did not reduce the rate of CD flare ups.[2380] However, the authors

note that reducing red meat intake might be beneficial for other health conditions.[2381]

To manage the symptoms of IBDs, patients may try a variety of different diets and food treatments, because not all individuals have the same dietary triggers.[2382,2383,2384] Patients managing IBDs therefore often follow diet regimens that are highly individualized to their specific needs.[2385] For example, IBD patients might try a variety of dietary changes to reduce symptoms, including avoiding high-fiber foods (such as vegetable skins and nuts), eating a high-calorie diet, eliminating lactose from the diet, or reducing salt intake.[2386]

Furthermore, according to a 2020 survey appearing in *Frontline Gastroenterology*, "Dietary advice [from healthcare providers to patients] in IBD is inconsistent reflecting uncertainty among healthcare professionals… With a striking lack of consistent dietary advice, it is not surprising that people with IBD frequently follow their own dietary rules."[2387] Advice from the National Institute of Diabetes and Digestive and Kidney Diseases is unspecific; patients with CD are suggested to keep a food journal to track their food triggers,[2388] and patients with UC are recommended to eat a "healthy diet."[2389]

"Guidelines for dietary recommendations and nutritional therapy for patients with inflammatory bowel disease (IBD) are lacking, and patients are moving toward popular defined diets for relief of symptoms and inflammation," wrote researchers in *Gastroenterology & Hepatology* in 2019.[2390] Many of these popular defined diets and food treatments have been studied for their effects on symptoms of IBD, such as a low-FODMAP diet,[2391,2392,2393,2394] an anti-inflammatory diet,[2395,2396,2397,2398,2399,2400] probiotic supplementation,[2401,2402,2403,2404] and the Mediterranean diet.[2405,2406,2407]. Most of the research into the efficacy of these dietary interventions, however, remains observational, and additional, randomized controlled studies are recommended.[2408]

Dietary Interventions for IBD

Among food-based interventions for IBD, low-FODMAP diets are the most studied, and a plethora of evidence supports their use.[2409] The acronym FODMAP refers to fermentable oligosaccharides, disaccharides, monosaccharides, and polyols,[2410] which are short-chain carbohydrates (sugars) that the small intestine absorbs poorly.[2411] Patients on a low-FODMAP diet refrain from consuming foods that contain these types of carbohydrates, including many fruits, vegetables, artificial sweeteners, dairy products, starches, and plant-based proteins, for six to eight weeks.[2412] Much published research, including observational studies and literature reviews, points to the efficacy of the low-FODMAP diet as part of a treatment plan for IBD, but researchers agree that more clinical studies, including randomized controlled trials, need to be conducted.[2413,2414,2415,2416]

Research has suggested that the Mediterranean diet may be a useful therapeutic tool for IBD due to its potential role in modulating gut inflammation.[2417,2418] A 2020 study of more than 100 adults with either UC or CD appearing in *Inflammatory Bowel Diseases* showed "improvement of disease activity and inflammatory markers" after adoption of the Mediterranean diet.[2419] However, according to a 2021 study appearing in *Nutrition & Dietetics*, the typical diets of many IBD patients align poorly with Mediterranean diet characteristics, suggesting that "dietary interventions focusing on improving the diet of individuals with inflammatory bowel disease to align with Mediterranean diet characteristics are warranted."[2420]

Another diet that is recommended to IBD patients is the Autoimmune Protocol (AIP) diet, which requires the elimination of grains, dairy, refined sugars, legumes, eggs, nuts, seeds, nightshades (e.g., tomatoes, potatoes, and eggplant), and food additives and increases the consumption of fermented foods.[2421] One 2017 prospective uncontrolled study appearing in *Inflammatory Bowel Diseases* of 15 adult patients found that the AIP diet improved symptoms in patients with UC and CD and 73 percent achieved clinical remission within six weeks of starting the diet.[2422]

Another diet that is recommended for patients with IBD is the Specific Carbohydrate Diet (SCD), which removes grains, refined sugars, processed and packaged foods, some legumes and dairy, and starchy vegetables from one's diet.[2423] A 2016 comparative analysis of the SCD published in *Nutrition* showed improvement in pediatric CD patients, as assessed by the Pediatric Crohn's Disease Activity Index, a validated instrument for measuring disease activity in children and adolescents.[2424] However, other retrospective surveys in both children and adults with CD and UC have shown mixed results, with only a subset of patients experiencing small improvements in disease outcomes.[2425,2426,2427,2428,2429]

Derived from the SCD is the Inflammatory Bowel Disease Anti-Inflammatory Diet (IBD-AID), which was developed by researchers at the University of Massachusetts Chan Medical School.[2430,2431] According to the developers of the diet writing in *Nutrition Journal* in 2014:

> The IBD-AID consists of lean meats, poultry, fish, omega-3 eggs, particular sources of carbohydrate, select fruits and vegetables, nut and legume flours, limited aged cheeses (made with active cultures and enzymes), fresh cultured yogurt, kefir, miso and other cultured products (rich with certain probiotics), and honey.[2432]

The IBD-AID has three phases based on the level of symptoms a patient is experiencing, each phase building upon the dietary allowances of the previous phase.[2433,2434] In a 2014 case series report published in *Nutrition Journal*, 100 percent of patients (n=11) placed on the IBD-AID reported a decrease in bowel frequency and were able to discontinue at least one of their prior IBD medications.[2435] The authors conclude, "The study of the IBD-AID would benefit from the rigorous analysis provided by a randomized clinical trial, with evaluation of mucosal healing and assessment of change in gut flora to examine the exact mechanism(s) of benefit."[2436] A 2021 review published in *Intestinal Research* summarized available data from studies that aimed to evaluate the effectiveness of the AID and concluded, "Lack of consistent data to support a practical recommendation of AID in managing IBD patients was noted due to various limitations present in previous research. It is necessary for clinicians advising IBD patients to have in-depth knowledge about the strengths and limitations of the IBD-AID nutritional regime to ensure its effectiveness as a therapeutic strategy."[2437]

Dietary Supplements and IBD

Some IBD patients have turned to dietary supplements as part of their treatment plans, and consume supplements such as curcumin.[2438,2439] Curcumin has been shown to inhibit the activation of transcription factors that lead to inflammation.[2440] A subsequent double-blind, placebo-controlled trial published in *Current Pharmaceutical Design* in 2009 reported that patients given curcumin were less likely than controls to have a recurrence in UC symptoms in the six months after treatment.[2441] Larger studies analyzing higher doses of the supplement are recommended to better understand its effect on IBD.[2442]

Another supplement that has been studied as a potential diet intervention for IBD is fiber,

derived from a variety of plant sources.[2443] A randomized controlled trial appearing in *Crohn's & Colitis* in 2020 reported the prevention of gastrointestinal symptoms among UC patients treated with 60 grams of oat bran a day,[2444] but additional studies are required to determine the long-term benefits of oat bran supplementation.[2445] According to a 2017 review in the journal *Nutrients*, two open-label trials (trials in which information is not withheld from participants) have found that 90 grams of germinated barley foodstuff a day reduced abdominal cramping and prolonged remission in UC patients.[2446] Germinated barley appears to be a safe maintenance therapy for adults with UC.[2447]

Several clinical trials have investigated the use of various species and strains of *E. coli* and *Lactobacillus* bacteria as treatments for IBD.[2448] The results do not appear as efficacious for patients with CD as they are for those suffering from UC.[2449] Three meta-analyses, conducted between 2009 and 2015, reported that some strains, including *E. coli* Nissle 1917 and *Lactobacillus* GG, were just as effective as mesalazine, a common medication for IBD, at preventing a relapse of UC symptoms.[2450,2451,2452] Two additional meta-analyses aimed at understanding the impact of probiotics on CD, however, concluded that supplementation with *Lactobacillus* GG and *Lactobacillus johnsonii* LA1 did not decrease the risk of relapse in CD patients.[2453,2454] Further study of the varying impacts of different strains and dosages on both UC and CD are needed to determine the patient populations that could benefit from probiotic treatment.[2455]

HIV/AIDS

Human immunodeficiency virus (HIV) is the virus that leads to acquired immunodeficiency syndrome (AIDS) by attacking certain infection-fighting cells in the immune system, making it difficult for the body to fight disease.[2456] The primary treatment for HIV infection is antiretroviral therapy (ART), medicine that is taken daily to reduce viral load,[2457] but the NIH also recommends good nutrition for patients living with HIV to maintain their immune systems.[2458]

People with HIV require a diet that promotes energy and is rich in protein and nutrients.[2459,2460] Diet quality has been found to be lower in PLWH compared to those without HIV.[2461] Factors that impact the diet quality of PLWH include HIV itself,[2462] the impacts of ART,[2463,2464] and the higher risk of PLWH for comorbidities such as high triglycerides, high cholesterol,[2465] heart diseases and type 2 diabetes.[2466,2467,2468] In 2003, the World Health Organization (WHO) developed nutrition recommendations for PLWH,[2469] followed by a 2005 review of evidence regarding the role of diet and nutrition in the efficacy of ART.[2470] Key recommendations from the report include:

- Adequate nutrition, which is best achieved through consumption of a balanced healthy diet, is vital for health and survival for all individuals regardless of HIV status.[2471]
- Improved attention to diet and nutrition may enhance ART acceptability, adherence and effectiveness.[2472]

The report highlighted that proper nutrition ensures the absorption of medication, reduces side effects, and helps maintain a healthy body weight.[2473,2474]

Specific micronutrients that are commonly deficient in PLWH include zinc, selenium, vitamin D, and vitamin A.[2475,2476,2477] Zinc and selenium help modulate the immune response of several cell types.[2478] Selenium has been shown to inhibit HIV replication pathways, and zinc is needed for T cell proliferation, helps with electrolyte absorption, and acts as an anti-inflammatory agent. Early studies in PLWH found a high prevalence of zinc deficiency in HIV patients.[24792480] Selenium deficiency is common in PLWH, correlated with CD4 counts (a measure of white blood cells that fight infection), viral load and disease progression.[2481] Foods high in selenium, including brazil nuts, tuna, and sardines, [2482] and foods high in zinc such as seafood, namely oysters, and beans are recommended for PLWH.[2483] Additional micronutrients that benefit PLWH include vitamin A, which can assist in increasing CD4 count,[2484] and vitamin D, which can address HIV-related bone problems associated with nutritional deficiency, HIV-infection, and ART interactions.[2485]

Alongside ART, medicinal plant extracts and specific foods have been found to have a beneficial impact on HIV viral loads.[2486,2487] Compounds found in garlic have shown protection against HIV replication, including ajoene, a sulfur-containing compound that has strong anti-HIV activity that blocks viral activity,[2488,2489] and garlicin, reported to inhibit HIV-1 viral replication.[2490] However, certain forms of garlic can significantly decrease the levels of some antiviral medications.[2491]

As a result of increased survival rates for PLWH due to the advancements in treatment and increased accessibility of ART, the population of people aging with HIV is increasing.[2492] Older adults with HIV are at even higher risk for age-related complications like bone loss[2493] and cardiovascular disease, compounded by their HIV status.[2494] With heightened risk of decreased muscle mass, memory loss associated with HIV and aging,[2495] PLWH within the aging population have an even greater need for adequate nutrition.[2496]

Food insecurity adversely impacts the ability to manage HIV.[2497,2498] For people living with HIV (PLWH), food insecurity is associated with poor medication adherence, poor immunologic and virologic outcomes, and morbidity.[2499] PLWH are frequently targeted by medically tailored meal providers in order to address food insecurity and ensure adequate nutrition.[2500,2501,2502] To learn more about medically tailored meals, see Part 3.

Hypertension (High Blood Pressure)

According to the American Heart Association, "Hypertension is when your blood pressure, the force of your blood pushing against the walls of your blood vessels, is consistently too high."[2503] Blood pressure is made up of two numbers: "Systolic pressure – the upper number in a blood pressure reading – measures how hard the heart pumps blood into arteries. Diastolic – the bottom number – indicates the pressure on the arteries when the heart rests between beats."[2504] In adults, high blood pressure is defined as systolic pressure above 130 with a diastolic pressure of 80 or higher.[2505]

One in every three Americans has hypertension, also known as high blood pressure.[2506] Hypertension can lead to dangerous complications including heart disease, stroke, kidney failure, congestive heart failure, and aneurysms.[2507,2508] In 2019, hypertension was a primary or contributing cause of over 500,000 deaths in the US.[2509] Of those in the US with hypertension, only one in four has their condition under control.[2510] Hypertension is also a common underlying

condition among patients hospitalized for COVID-19;[2511] according to the CDC, “people whose only underlying medical condition is hypertension might be at increased risk for severe illness from COVID-19.”[2512]

Although there are genetic influences on blood pressure, diet also has a significant impact.[2513] A 2018 study appearing in *JAMA Cardiology* of the blood pressure levels of indigenous Yanomami and Yekwana individuals in Venezuela demonstrated that increases in blood pressure might not be a natural result of aging, but rather a consequence of other factors such as diet.[2514] In societies where salt intake is low, hypertension occurs at much lower rates.[2515,2516] The recommended daily intake of salt is less than 2,300mg, or less than a teaspoon, but many processed foods and fast foods can exceed that amount in just one meal.[2517,2518]

Researchers have shown that obesity is a significant risk factor for many health conditions including hypertension.[2519,2520,2521] According to the CDC, “Weight that is higher than what is considered healthy for a given height is described as overweight or obesity. Body Mass Index (BMI) is a screening tool for overweight and obesity.”[2522] BMI is is a person’s weight in kilograms divided by the square of height in meters, and a BMI from 25 to <30 is categorized as overweight and a BMI of 30 or higher is categorized as obese.[2523]

Research has demonstrated that obese individuals have a three fold increased liklihood of hypertension.[2524] According to the CDC, “Having obesity or being overweight means your heart must work harder to pump blood and oxygen around your body. Over time, this can add stress to your heart and blood vessels.” A 2016 review highlighted that several biological mechanisms underlie the association between obesity and hypertension: “Activation of the sympathetic nervous system (SNS), the amount of intra-abdominal and intra-vascular fat, sodium retention leading to increase in renal reabsorption, and the renin-angiotensin system, are considered to have important functions in the pathogenesis of obesity-related hypertension.”[2525] While obesity is an increased risk factor for hypertension, weight loss of as little as ten pounds has shown to be effective in reducing blood pressure.[2526,2527]

The National Institutes of Health National Heart, Lung, and Blood Institute (NHLBI) recommends the DASH (Dietary Approaches to Stop Hypertension) eating plan for people managing hypertension.[2528] This eating plan does not consist of specific foods, but rather provides broader nutritional guidelines:

- Consuming vegetables, fruits, and whole grains
- Including fat-free or low-fat dairy products, fish, poultry, beans, nuts, and vegetable oils
- Limiting foods that are high in saturated fat, such as fatty meats, full-fat dairy products, and tropical oils such as coconut, palm kernel, and palm oils
- Limiting sugar-sweetened beverages and sweets[2529]

In a 2020 systematic review appearing in *Advances in Nutrition*, researchers concluded that adoption of the DASH diet resulted in significant reduction in blood pressure levels.[2530] The authors also noted that “no differential [blood pressure] effect was noticed between hypertensive and nonhypertensive patients,” so people not diagnosed with hypertension can also benefit from the diet’s blood pressure-lowering effects.[2531] According to a 2018 review published in *Clinical Nutrition ESPEN*, the DASH diet may also have beneficial effects on the alterations of blood

pressure, overweight, and obesity among adolescents, [2532]

Several other dietary changes have been studied for their impact on treating and managing hypertension. A 2018 study appearing in *Clinical Cardiology* showed that following a plant-based dietary intervention might be an effective approach to treatment for hypertension.[2533] This dietary intervention used a food classification system that emphasized raw fruits and vegetables.[2534]One 2021 review from the journal *Nutrients* assessed the link between hypertension and the ketogenic diet, concluding:

> Available data seem to suggest that [ketogenic diets] are able to provide a reduction in blood pressure values but do not induce significantly different changes compared to non-ketogenic diets. These data suggest that the antihypertensive effects of [ketogenic diets] are not directly related to the precise metabolic consequences induced by ketosis but rather indirectly due mainly to weight loss.[2535]

Individuals with hypertension are frequently targeted by various food prescription programs as a way to increase access to fruits and vegetables.[2536,2537] To learn more about produce prescription programs see Part 3.

Mental Health Conditions and Illnesses

According to the National Institutes of Health National Institute of Mental Health (NIMH), mental illnesses can include many different conditions that vary in degree of severity and can be grouped into two broad categories described below:

> Any mental illness (AMI) is defined as a mental, behavioral, or emotional disorder. AMI can vary in impact, ranging from no impairment to mild, moderate, and even severe impairment. Serious mental illness (SMI) is defined as a mental, behavioral, or emotional disorder resulting in serious functional impairment, which substantially interferes with or limits one or more major life activities.[2538]

It is estimated that mental illness affects 52.9 million people (one in five adults) and serious mental illness affects 14.2 million people (one in 20 adults) in the United States.[2539] Depression and anxiety are the most common mental health conditions, making them a leading cause of disability worldwide.[2540]

Standard treatment for mental health conditions can include the use of evidence-based medications, therapy and psychosocial services; however, it is estimated that in 2020 less than half (46 percent) of those with mental illness received mental health services.[2541] The emerging field of nutritional psychiatry explores the adjunct role of food and nutrition in the prevention and treatment of mental health conditions. In a review of the nutritional psychiatry literature published by *Cambridge University Press* in 2017, the authors advocate for additional strategies to prevent and treat mental health that integrate evidence on the role of food and nutrition:

> Treatment is presently dominated by pharmacotherapy, such as antidepressants, and psychotherapy, such as cognitive behavioural therapy; however, such treatments avert less than half of the disease burden, suggesting that additional strategies are needed to prevent and treat mental disorders. There are now consistent mechanistic, observational and interventional data to suggest diet quality may be a modifiable risk factor for mental illness.[2542]

Epidemiological studies have demonstrated a consistent association between nutrition and mental health.[2543] Several systematic reviews have shown healthy dietary patterns (characterized by high intake of vegetables, fruit, wholegrains, nuts, seeds and fish, with limited processed food) to be inversely associated with the risk of depression.[2544,2545,2546] Conversely, diets consisting of processed, high-fat, high-sugar foods are associated with mental disorders such as depression and anxiety, as well as other neuropsychiatric conditions (conditions that have both neurological and psychiatric features).[2547,2548] Additionally, vitamin deficiencies have also been shown to impair mental health and cognition.[2549,2550,2551] The link is strongest for vitamin B12 deficiency which has been shown to affect cognition, cause brain shrinkage, and can be associated with depression.[2552,2553,2554,2555] Deficiency in omega-3 fatty acids has also been linked to a higher risk of depression and suicide.[2556]

Research has also demonstrated that food can affect the chemical composition of the brain and impact mood.[2557] In 1995, Richard Wurtman, M.D. and Judith Wurtman, Ph.D., researchers at the Massachusetts Institute of Technology (MIT), published a review in *Obesity Research* outlining how carbohydrate foods boosted the production of serotonin, a neurotransmitter that controls mood, sleep, and appetite, and, when elevated, helps you to feel more relaxed and calm.[2558] This research has shown that glucose in high carbohydrate food triggers the release of insulin which in turn allows the amino acid tryptophan to reach the brain (by blocking other competing amino acids), stimulating the production of serotonin.[2559] Other research has shown that dietary protein raises the level of the amino acids tyrosine and phenylalanine, which produce the neurotransmitters dopamine and norepinephrine, which are brain chemicals that play a role in mood, motivation, and concentration.[2560] Refined sugar intake (e.g. sugar-sweetened beverages) has been linked to increased rates of depression, possibly by altering endorphin levels and oxidative stress.[2561,2562] Vegetable oil, which contains many types of dietary fat, has also been shown to activate endorphin neurons in the hypothalamus in rats.[2563,2564]

Fruit and vegetable consumption has also been shown to have an impact on mood.[2565,2566,2567] A 2021 study published in *Clinical Nutrition* found that fruit and vegetable intake was inversely associated with perceived stress across the adult lifespan.[2568] The study indicated that "people who ate at least 470 grams of fruit and vegetables daily had 10 per cent lower stress levels than those who consumed less than 230 grams."[2569] The WHO recommends a minimum daily intake of 400 grams of fruits and vegetables.[2570] A 2016 study published in the *American Journal of Public Health* found that increased fruit and vegetable consumption was predictive of increased happiness, life satisfaction, and well-being and noted that improvements in happiness were seen long before any physical improvements.[2571] Another study published in *Frontiers of Psychology* in 2018 demonstrated that intake of raw fruits and vegetables was associated with better mental health than intake of processed fruits and vegetables.[2572] The gut-brain axis, which refers to the communication between the gut and the brain via neural, endocrine, and immune pathways, has been shown to influence mood and mental health.[2573] The communication works both ways, with the brain capable of influencing gut activity and the gut influencing mood, mental health, and cognition.[2574] Evidence shows that gut microbiota can profoundly affect the relationship between gut and brain, including influencing mental state and

emotion regulation.[2575] Other research shows that proper maintenance of gastrointestinal homeostasis results in improved cognitive function and motivation.[2576] Evidence also shows that several mood disorders, including anxiety and depression, are directly linked to gastrointestinal problems.[2577,2578]

Research suggests that regulating gut activity can result in improved mental health.[2579,2580] A study published in *Scientific Reports* in 2021 looked at anxiety in women ages 18 to 25 and found that galacto-oligosaccharides (GOS) prebiotics (taken as dietary supplements) was associated with a decrease in high trait anxiety and an increase in bacterial abundance.[2581] GOS prebiotic supplements are commercially-available and might be taken to improve anxiety symptoms.[2582] These findings suggest that prebiotic supplementation may improve indices of pre-clinical anxiety.[2583]

Additionally, mental health disorders have been linked to food insecurity. According to the 2011-2014 National Health Interview Survey, working-age adults (aged 25-61) living with a mental health disability have a 11.3 percent chance of living in a food insecure household.[2584] A 2017 study published in the *American Journal of Preventive Medicine* analyzed cross sectional data from the 2014 Gallup World Poll, a series of globally implemented, nationally representative surveys, and found that food insecurity was associated with poorer mental health and specific psychosocial stressors across 149 countries.[2585] A study published in *Pediatrics* found that household food insecurity was related to 27.9 percent higher rates of depressive symptoms in children.[2586] Researchers recommend holistic approaches to address these interconnected problems and protect children against food insecurity.[2587]

Some researchers have questioned where the relationship between food insecurity and mental health originates:[2588] Does food insecurity cause poor mental health, or does poor mental health lead to food insecurity? The two issues have a "bidirectional association whereby food insecurity increases the risk of poor emotional health, and poor emotional health increases the risk of food insecurity," according to reviewers in a 2017 article appearing in *Public Health Nutrition*.[2589] Various factors have been theorized to explain this relationship. People suffering from mental health disorders might have higher costs of living, leaving less money to spend on food.[2590] Researchers writing in *BMC Public Health* in 2021 have also proposed that stigmas associated with food assistance might lead to poor mental health during the COVID-19 pandemic:

> The stigmatization of receiving food assistance might have increased anxiety and depression for those who were not food insecure before, which may help explain why food insecurity is more associated with anxiety and depression than losing a job during the pandemic.[2591]

Additionally, people with mental health disorders might have a more difficult time "maintain[ing] (or resum[ing]) employment and adequate income supplements for…sufficient financial resources to maintain adequate nutrition," write researchers in *Public Health* in 2016.[2592]

Dietary Interventions

In a review published in *Molecular Psychiatry* in 2020, the researchers explored the underlying mechanisms of action by which diet may influence mental and brain health and highlighted the importance of tryptophan available for metabolism in the management of mental health.[2593] The authors also noted the need for more research into the associations between dietary tryptophan and mental health: "In the context of using dietary interventions for mental health prevention and treatment, understanding tryptophan availability and metabolism may be important."[2594]

A 2014 systematic review of randomized controlled trials published in *Public Health Nutrition* reviewed dietary interventions that used depression or anxiety as an outcome and sought to identify characteristics of program success.[2595] The review found mixed results with

> [A]pproximately half the studies reporting improvements in outcomes, with successful trials generally including at least one of the following: single delivery mode (e.g. single or group face-to-face meetings only), employment of a dietitian, explicit recommendation of a diet high in fibre and/or fruit and vegetables. These trials were also less likely to recommend weight loss, reduce red meat intake or follow a low-cholesterol diet.[2596]

The ketogenic diet has been proposed as a potential therapy for mood disorders such as bipolar,[2597] but more robust trials and research is needed to determine the efficacy of the diet in treating mental health disorders.[2598]

The SMILES trial, which was published in *BMC Medicine* in 2017, was the first randomized controlled trial intervention study to test dietary improvement as a treatment approach for depression.[2599] The dietary intervention comprised personalized counseling from a clinical dietician in order to support optimal adherence to the recommended Mediterranean diet and was compared to a control group that received social support. Those in the dietary intervention group learned about the Mediterranean diet and were encouraged to consume more whole grains, vegetables, fruit, legumes, low-fat and unsweetened dairy foods, raw and unsalted nuts, fish, lean red meats, chicken, eggs, and olive oil.[2600] They were also encouraged to reduce their intake of sweets, refined cereals, fried food, fast food, processed meats, and sugary drinks. The dietary support group had significant improvement in the consumption of the recommended food groups and significantly greater improvements in depressive symptoms compared to the control group.[2601] Study results provide preliminary evidence that dietary interventions in clinically diagnosed populations are feasible and may provide clinical benefit.[2602,2603]

The burgeoning field of nutritional psychiatry is supported by epidemiological studies that have demonstrated a consistent association between nutrition and mental health[2604] and emerging findings from clinical trials suggest that dietary interventions may play a beneficial role in the treatment of mental health conditions.[2605] Drew Ramsey, M.D, an assistant clinical professor of Psychiatry at Columbia University and is one field's leading proponents of nutritional psychiatry.[2606] Dr. Ramsey founded the Brain Food Clinic in New York City, an integrative mental health clinic which incorporates evidence-based nutrition and integrative psychiatry treatments with psychotherapy, coaching, and medication management in the treatment of depression, anxiety and emotional wellness concerns.[2607] In a 2019 New York Times article Dr. Ramsey stated, "We can't control our genes, who our parents were, or if random acts of trauma or violence happen to us, but we can control how we eat, and that gives people actionable things that they can do to take care of their brain health on a daily basis."[2608]

Most studies to date looking at the relationship between diet and mental illness have been observational and do not provide information about causality or underlying mechanisms.[2609] Additional research is needed to elucidate on the underlying mechanisms between nutrition and mental health and explore the effectiveness of various dietary

interventions.[2610] However, emerging findings from clinical trials suggest that dietary interventions may play a beneficial role in the treatment of mental health conditions.[2611]

Multiple Sclerosis

Multiple sclerosis (MS) is a disease of the central nervous system that affects the brain and spinal cord by causing damage to the myelin sheath, the material that surrounds and protects nerve cells.[2612] This damage hinders communication between the brain and the body, which causes symptoms of MS, including muscle weakness, memory problems, and more.[2613] Epidemiologic research suggests that dietary factors may play a significant role in the development and course of the illness.[2614] And while the cause is unknown, there is strong evidence that it is an immune-mediated disease (a dysfunction of the immune system).[2615] There is no known cure, but several nutrition and dietary interventions have been shown to alleviate symptoms and slow the progression of the disease.[2616,2617]

The nutritional status of MS patients has not been extensively studied, but findings suggest that many MS patients also suffer from various forms of malnutrition, including weight loss, vitamin deficiency, or obesity.[2618] These problems have been associated with impairment of the immune system.[2619] High levels of low-density lipoprotein (LDL) cholesterol and vitamin D deficiency are both associated with risk of MS.[2620,2621,2622] Studies have also shown that a high salt diet might contribute to an increased risk of developing MS.[2623,2624]

Various diets have been studied for their efficacy in managing MS symptoms, including the ketogenic diet,[2625] the paleo diet,[2626,2627,2628] the Mediterranean diet,[2629] low-fat diets,[2630,2631] and a very-low-fat plant-based diet.[2632] In one pilot study of a modified Mediterranean diet appearing in *Multiple Sclerosis and Related Disorders* in 2019, researchers found that the dietary intervention resulted in reduced fatigue, disability, and symptoms among MS patients.[2633] Furthermore, studies have shown the efficacy of a modified paleo diet that "consisted of leafy green and sulfur-containing vegetables, intensely colored fruits and vegetables, plant and animal proteins, seaweeds, and nondairy milks" while avoiding gluten-containing grains, eggs, and dairy products.[2634,2635] In a 2017 randomized controlled trial published in the journal *Degenerative Neurological and Neuromuscular Disease* measuring the effects of this diet on quality of life among MS patients, improvements were seen on many fronts:

> Important health-related improvements in perceived fatigue, physical and mental health [quality of life], and dominant hand motor function were observed along with increased vitamin K serum levels in the [modified Paleolithic diet] group compared to the control group postprotocol.[2636]

One popular diet followed by some people managing MS is called the Swank diet, designed and promoted by Roy L. Swank, MD, PhD, a neurologist and longtime researcher of potential treatments for MS.[2637] The Swank diet recommends less than 15 grams of saturated fat consumption daily (compared to ~20 grams per day recommended by the 2020-2025 Dietary Guidelines for Americans[2638]), five grams of cod liver oil, 40-50 grams of vegetable or fish oil, one egg, a multivitamin, whole wheat bread, and fish more than three times per week.[2639] A 2019 analysis of the Swank diet in comparison to the Dietary Guidelines for Americans published in *Nutrients* found that the Swank diet meets nearly all of the Recommended Dietary Allowances (RDAs) from the Dietary Guidelines for Americans.[2640] Swank diet menus were within the Acceptable Macronutrient Distributions (AMDRs) for protein, fat, and carbohydrates.[2641] The diet also recommends patients supplement their diets with vitamin E, fish oil, and a multivitamin.[2642] However, while patients on this diet typically meet the recommended levels of vitamins D and E, folate, calcium and iron, supplementation does not correct shortfalls in dietary fiber, potassium or choline.[2643] With specific selection of foods to ensure adequate intake of daily fiber, potassium and choline, the Swank diet continues to be one of the most promoted dietary regimens for people with MS, though additional research is needed to assess adherence, nutritional adequacy, and impact of the diet on the disease course of MS.[2644]

Another dietary intervention that has been studied inpatients with MS is vitamin D supplementation, which has been shown to have a positive impact on inflammation symptoms in MS patients.[2645] Flavonoids (organic compounds rich in antioxidants) with phytopigments that are found in fruits and vegetables may be a protective agent to address shifts in the immune system (immunomodulation) and loss of structure in the neurons (neurodegeneration), both of which are characteristics of MS.[2646,2647] Evidence suggests that diets low in fat with omega-3 polyunsaturated fatty acid supplements can decrease the severity of physical and mental MS symptoms.[2648]

According to a 2020 Cochrane systematic review of dietary interventions for the treatment of MS, "At present, there is insufficient high certainty evidence as to whether dietary interventions change the course of MS…Future research of dietary interventions in MS should implement higher quality research methodology to limit the potential for bias."[2649] However, the reviewers note that dietary intervention is a common strategy used by patients with MS, writing, "As conventional therapies are only partially effective, people with MS widely use complementary and alternative medicine (CAM) with dietary interventions among the most popular form of CAM."[26502651]

Sleep

Research shows that our diets have an impact on our ability to both fall asleep and maintain sleep.[2652,2653,2654,2655] One 2014 study appearing in the *Journal of Occupational Health* showed that a high intake of carbohydrates resulted in poor sleep quality while a high intake of fish and vegetables was linked to improved sleep quality.[2656] Additionally, a 2020 study appearing in the *Journal of the American Heart Association* showed that "overall sleep quality was associated with consumption of certain nutrients and foods associated with disease risk," such as added sugar.[2657]

Another 2013 study appearing in the *Journal of Epidemiology* showed that a lower-than-normal protein intake was associated with difficulty falling asleep and poor quality sleep while higher-than-normal protein intake resulted in trouble maintaining sleep.[2658]

However, according to a 2016 review appearing in *Advances in Nutrition*, "it is unknown whether it is sleep that affects dietary intakes or dietary intakes that affect sleep."[2659] Therefore, some research has been conducted to examine the impact of

individuals' sleep patterns on their ability to maintain a diet high in foods perceived as "healthy," including a 2013 study appearing in the *International Journal of Obesity*.[2660] In this study, participants who got only four hours of sleep experienced greater brain rewards (such as pleasure) when looking at unhealthy foods like pizza, doughnuts, and candy compared to when they got nine hours of sleep.[2661] These results suggest sleep restriction alters the body's response to foods.[2662] The researchers noted, "Although we believe that all foods have a place as part of a healthy diet, foods established as being unhealthy such as candy and ice cream may produce feelings of guilt regardless of their calorie content."[2663] One's ability to get a good night's sleep is positively correlated with maintaining a healthy diet.[2664,2665] According to Dr. Susan Redline, a physician as well as a professor of sleep medicine at Harvard Medical School, "The takeaway is that diet and sleep are entwined. Improving one can help you improve the other and vice versa, creating a positive cycle where they perpetuate one another."[2666]

Some individuals turn to dietary supplements, notably melatonin, as sleep aids.[2667,2668] According to the NCCIH, "Melatonin is a hormone that your brain produces in response to darkness. It helps with the timing of your circadian rhythms (24-hour internal clock) and with sleep."[2669] Multiple Cochrane systematic reviews of the impact of melatonin on sleep quality, quantity, and duration have found little to no high-quality evidence supporting its use.[2670,2671,2672,2673] Side effects of melatonin supplementation are poorly understood, so the NCCIH advises that people talk to their health care providers about use of supplements, including melatonin.[2674]

Another compound frequently associated with sleep is tryptophan, described by the National Library of Medicine's PubChem as:

> …the least plentiful of all 22 amino acids and an essential amino acid in humans (provided by food). Tryptophan is found in most proteins and a precursor of serotonin. Tryptophan is converted to 5-hydroxy-tryptophan (5-HTP), converted in turn to serotonin, a neurotransmitter essential in regulating appetite, sleep, mood, and pain. Tryptophan is a natural sedative and present in dairy products, meats, brown rice, fish, and soybeans.[2675]

Some studies have shown that tryptophan might be effective as a sleep aid. According to a 2021 article published in *Nature and Science of Sleep* analyzing survey data from 7,890 Chinese adults, researchers found that higher intake of dietary tryptophan was positively associated with sleep duration.[2676] A 2022 review appearing in *Nutrition Reviews* showed that tryptophan supplementation might improve sleep quality.[2677] About the potential uses for tryptophan, the National Library of Medicine writes, "People use L-tryptophan for severe PMS symptoms, depression, insomnia, and many other conditions, but there is no good scientific evidence to support any of these uses."[2678]

Part V
Recommendations

PART V

Recommendations

Incorporating food as medicine practices into traditional healthcare is a strategy that medical professionals, insurance companies, policymakers, community organizations, and other key stakeholders must explore to effectively prevent and treat chronic disease, lower health care costs, and improve patient quality of life. Food and dietary modifications can be included as a part of treatment for a variety of diseases and conditions, in conjunction with modern medical treatments.

This report, with more than 2,500 citations and the curation of more than 650 studies, systematic reviews, meta-analyses, and other peer-reviewed journal articles, aims to serve as a bridge between food-based treatment and traditional medicine, demonstrating that both should be considered to most effectively prevent and treat disease. There are still significant opportunities for further research, which have been outlined in this report.

The goal of this report is to bridge the gap between traditional medicine and the use of food as medicine in the prevention and treatment of disease. It is our hope that this report will serve as a foundation for understanding the potential uses of food and diet as a therapeutic mechanism.

The Center for Food as Medicine and the Hunter College NYC Food Policy Center have compiled the following recommendations for healthcare professionals, insurance companies, policymakers, community organizations, and other key stakeholders to consider when designing food as medicine interventions, programming, policies, and research. The two Centers make these recommendations to contribute to a healthier and more equitable future for all.

- **Evaluate the impact of food on the prevention and treatment of disease.**
  - Congress must approve increased funding to the NIH to provide grants to researchers specifically focused on the use of food in prevention and treatment of disease, potentially reducing the dependency that many researchers currently have on funding from the food industry.
  - Topic areas for funded research should include:
    - Specific dietary patterns and interventions on the prevention and treatment of disease.
    - Traditional medicine practices from around the world in the prevention and treatment of disease. Practitioners of these traditional medical practices should be involved in the design and implementation of these studies.
    - Food as medicine programs (such as medically tailored meals and produce prescriptions) on health outcomes.
    - Incorporate foods and dietary patterns from many different cultures into this research to ensure food interventions are culturally appropriate for all participants.
  - Research should include robust clinical trials with large sample sizes necessary to evaluate the efficacy of the above approaches.
  - Invest in research to identify and tailor effective implementation of food as medicine programs for at-risk communities in a variety of settings.

- **Create and maintain a central repository that identifies all current food as medicine programs and interventions operating in the United States.**
  - The central repository will identify all existing food as medicine programs in the United States (including nutrition incentive and voucher programs, medically-tailored meals programs, produce prescription programs, and culinary medicine and education programs).
  - The repository should be developed to serve as a central access point for food as medicine programs and interventions, where stakeholders can easily engage with existing programs for referrals and obtain up to date information to disseminate to target audiences.
  - The repository should also provide food as medicine program leaders with opportunities to connect and collaborate (e.g., creation of listservs and forums).

- **Disease-Specific Food as Medicine Research and Resource Guides: Create, curate, and update daily disease specific food as medicine research and resource portals / guides to translate and disseminate peer-reviewed, evidence-based research to academics, researchers, physicians, physician extenders , individuals, caregivers, and family members of those diagnosed as well as the general public. These guides will use evidence-based research to dispel myths and pseudoscience and bridge the gap between traditional medicine and the impact of food on disease.**
  - The resource guides should be created and updated for specific health states such as Multiple Sclerosis, Autism, Diabetes, Crohn's, Alzheimer's, and Depression.
  - Each resource guide will summarize the disease, how diet can positively or negatively impact it, and specific foods to manage and treat the disease.
  - Each resource guide will be formed with evidence-based research that has undergone critical analysis by health professionals and scientists. The resource guides should be tailored for a variety of audiences and be available at no cost on the internet.
  - See the Center for Food as Medicine's Food as Medicine Resources and Research Guides as an example.

- **Develop a robust infrastructure of experts (e.g., Medical Schools, Academic Centers, Non-profits dedicated to Food As Medicine, Divisions of the NIH) who can navigate the copious research that has already been conducted in the food as medicine space and translate this research to physicians, health care providers, caregivers, and patients.**
  - Government agencies and academic institutions should fund the creation and maintenance of multiple academic centers dedicated to investigating the state of the science, looking through the existing evidence to highlight the highest quality work, and curating current evidence about the relationship between food and disease.
  - These centers will be dedicated to combating misinformation and potentially harmful practices with evidence-based, accurate information about the uses of food in the prevention and treatment of disease.
  - These centers can provide health care providers, individuals, caregivers, and stakeholders interested in food as medicine with information about the most recent developments in research and the uses of food in the prevention and treatment of disease.
  - These centers can maintain guides and best practices for organizations and health care settings that operate food as medicine programs (such as medically tailored meals, food prescriptions, and culinary medicine).

- **Mandate education about nutrition and the role of diet in the prevention and treatment of disease within educational curricula for physicians and health care providers (e.g., nurses, physician assistants, nurse practitioners).**
  - Require a series of nutrition courses among the earliest core requirements in medical school curricula that provides all medical students with a background on the role of diet in the prevention and treatment of disease. Courses would include:
    - Basic Nutrition
    - The Role of Food in the Prevention and Treatment of Disease
    - Food as Medicine Programming and Interventions (medically tailored meals, culinary medicine, food prescriptions)
    - Food Insecurity: Causes, Effects, and Solutions
    - Dietary Supplements, Nutraceuticals, and Functional Foods
    - The Role of Food in Traditional Medical Practices Around the World
    - Interacting with Patients about Diet, Lifestyle, and the Impact of Food on Disease
  - Require a series of nutrition courses in health care provider education/training that highlights the role diet plays in the prevention and treatment of disease.
  - Develop Continuing Medical Education courses centered on food as medicine topics, including popular food as medicine programs and current evidence about the role of food in the prevention and treatment of specific diseases.
  - Develop detailed competencies for physicians and health care providers to support Food as Medicine including ongoing training and education on:
    - How to apply client/patient-centered principles to all food as medicine programs and interventions.
    - Understanding the interaction of food, medicine, disease, and policy.
    - Understanding the history of food as medicine and respecting the knowledge, wisdom, and practices that have been passed down for thousands of years.
    - Developing effective and ethical communication skills and techniques to achieve desired goals and outcomes.
    - Applying knowledge of foods, cultural foods, eating patterns, and food trends in treatment and counseling of patients.

- **Hospitals should be a model for advancing food as medicine and integrating dietary evidence for the prevention and treatment of disease into institutional practices and programs.**
  - Hospital administrators and leaders should be provided with up-to-date resource guides containing the current state of evidence on the role of food in the prevention and treatment of disease as well as existing policies and programs that can be integrated into hospital systems.
  - Federal, state, and local government agencies should provide financial incentives and guidance to public and private hospitals and healthcare settings that develop and maintain food as medicine programs, including medically tailored meals and produce prescriptions.
  - There must be a complete overhaul of the meals served at hospitals to ensure that hospital food is medically-tailored to address disease and support health, and provides a foundation for the use of food as a therapeutic
    - Every meal served at a hospital should be made considering the specific nutritional needs of the patient and their specific disease state, based on the latest and most prevailing science.
    - Hospitals should provide a variety of different meal options for the diverse cultural backgrounds of patients.
    - Hospitals should hire chefs to create meals or purchase meals from a vendor that are delicious and tailored to the individual nutritional, medical, cultural, and religious needs of patients.
    - Hospitals should provide meals that are easy and simply duplicated by their patients which would allow them to prepare nutritionally sound meals in their own homes. Patients should be provided with easy-to-follow recipes specifically tied into available foods within that patient's community.
    - Whole-food, plant-forward scratch cooking should be prioritized in all hospital kitchens.
    - Ultra-processed foods, unhealthy fats, and high fructose corn syrup must be banned completely from hospital cafeterias.
  - Create screening questions for healthcare providers to identify relevant food as medicine interventions for patients and require that health care providers integrate nutrition assessment into clinical workflows.
  - Provide physicians with robust, evidence-based guides and literature about the state of the science regarding food's impact on prevention and treatment of disease.

- **Enhance and advance public awareness of the role of food in relation to the prevention and treatment of disease.**
  - Nutrition and food education must begin early.
    - Public schools should integrate courses into their core programming about basic food, nutrition and agriculture.

- Publicly funded child care centers should incorporate some form of nutrition and food education containing interactive lessons about physical activity and healthy eating.
- Create school gardens in public schools and utilize these gardens as a hands-on approach to teaching students about food and nutrition.

o Healthcare settings and community organizations should provide individuals, caregivers, and family members of those diagnosed with a disease with evidence-based research about the role that diet and nutrition can play in health and disease. This information should be updated regularly and tailored to meet health literacy and language needs.. This should be provided in a variety of formats, including on disease-specific microsites, in email newsletters, and in print.

o De-stigmatize conversation regarding the prevention and treatment of disease with traditional medical practitioners, encouraging health care providers and patients to have open discussions about treatment other than pharmaceuticals.

o Design food and nutrition programs for various audiences that take into account factors relevant to particular individuals, groups, and communities.

- Assess the population's readiness to learn and identify barriers to learning.
- Translate basic to advanced food and nutrition science knowledge into language that is understandable and tailored to the audience being addressed.
- Integrate current research and evidence-informed practice findings into delivery of safe and effective nutrition and medical care.
- Increase cultural variety of options available to participants in food as medicine programs.

• Increase community access to culturally appropriate, unprocessed, fresh, whole foods and food as medicine programs for the prevention and treatment of disease.

o Support the expansion of sources of fresh fruits and vegetables (such as farmers' markets, produce carts, supermarkets, food co-ops, community-supported agriculture boxes, and other environments where fresh fruits and vegetables can be purchased) in communities that lack retail access to fruits and vegetables.

- Improve community access to culturally appropriate fresh, whole foods to ensure that all people have resources in their neighborhoods to food that they can tailor to their cultural, preferential, and medical needs.

o Determine the most effective communication strategies for the dissemination of information about the role of food in the prevention and treatment of disease and existing food as medicine programs and interventions to a wide variety of audiences.

- Government agencies and offices (such as local representative offices, health department offices, and public school administration offices) should distribute information about available food as medicine interventions and programs to constituents.
- Utilize social media, email, physical mail, posters at SNAP and WIC enrollment centers, and other forms of media to inform recipients of federal nutrition programs about food as medicine programs and interventions available to them.

o Improve coordination between health insurance companies (including Medicaid and Medicare) and healthcare settings in order to identify and connect patients to existing food as medicine programs.

o Health insurance companies must offer coverage for a wide variety of food as medicine programs and individualized nutrition counseling in the treatment of chronic diseases.

- Increase access to government-funded health care coverage for individualized nutrition counseling with Registered Dietitians for preventative screening and care as well as for medical nutrition therapy (MNT) specific for a variety of chronic conditions. Currently, MNT is only covered for patients with diagnosed diabetes and kidney disease; Medicare and Medicaid must cover MNT more disease and conditions.

o Develop and support initiatives that prioritize whole-food, plant-based diets.

o Invite continuous feedback from community members to ensure food as medicine interventions are culturally mindful and feasible by participants.

• Congress must increase federal funding for the development of a wide variety of food as medicine programs including medically tailored meals, produce prescriptions, and nutrition incentives. There should not be only one food as medicine program option in a given community, due to the variety of logistical, resources, availability and access of potential participants.

• Expand and improve federal, state, and local policies that promote food and diet in the prevention and treatment of disease.

o Update the Dietary Guidelines to reflect contemporary evidence about the relationship between diet and disease while avoiding influence from large corporations in the food industry.

o Regulate terminology used by companies marketing health and wellness food products and supplements.

- Create specific, FDA-regulated definitions for terms such as "natural," "functional food," and "nutraceutical."
- Develop a federal oversight board that tests nutraceuticals and dietary supplements to ensure these products contain exactly the ingredients they claim.

o Expand and improve food assistance programs, including the Supplemental Nutrition Assistance Program (SNAP), the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)

- Increase the minimum benefit amount for all SNAP and WIC recipients, giving them more purchasing power.
- Increase the bonus amounts provided by nutrition incentive programs (such as New York City's Health Bucks provided by farmers' markets) so that participants can purchase more fresh, whole foods.
- Design and promote programs that not only facilitate access to fresh, whole foods, but also provide context as to why certain foods impact overall health.
- Expand SNAP pilots that allow recipients to purchase prepared meals with an emphasis on nutrition as opposed to cost per meal.
- Provide equipment to retailers to allow them to accept SNAP, eWIC, and other healthy food incentives electronically.
- Facilitate the expansion of food purchases made with SNAP online and wirelessly.

References & Methodology

Methodology

For this narrative review, two electronic databases (PubMed and Google Scholar) as well as Google and Google News were searched from their inception through March 2022. The search strategy included such key search terms as, but was not limited to: “food as medicine”, “food is medicine”, “culinary medicine”, “culinary nutrition”, “medically tailored meals”, “medically tailored groceries”, “medically tailored food packages”, “food for health”, “nutritious food referrals”, “prescription fruit and vegetable programs”, “using food for disease management”, and “community-level healthy food programs”. Searches were conducted only in the English language. The preferred citations were academic journals with an impact factor of 3.5 or higher on the given topics. However, citations were not necessarily disqualified if the journal had an impact factor lower than 3.5. A snowball method was used to search for articles not identified in the initial search. In addition, a search of the grey literature was conducted. No restriction was placed on the year of publication for the included reports, however preferred citations were published in the past five years (2017 to present).

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