

Research Update on Diet

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The foods we eat impact how long and how well we live. A healthy diet is known to help prevent the deadliest chronic diseases in the U.S., including cardiovascular disease, cancer, and diabetes. Eating a healthy diet also helps us to maintain other components of Healthy Living; it has been linked to better sleep, healthy weight management, and provides needed fuel for physical activity.

But what exactly constitutes a healthy diet? Challenges in the field of nutrition science have prevented researchers from agreeing on any one diet type as a universal gold standard, but there does tend to be broad agreement on the benefits of consuming vegetables, fruits, and fiber, and the need to reduce sugar, refined grains, and ultra-processed foods.¹

In this update, we will explore why rigorous nutrition experiments are so difficult to accomplish and take a look at some recent information about the health benefits of plants and fiber, ranging from individual immune health to global environmental health. In the absence of definite answers, this report summarizes recent thinking and best practices about eating for a healthy long life.

Challenges of nutrition science

While it may at first glance seem straightforward to identify healthy foods, nutrition science has proven to be extremely difficult to implement in practice. The issue does not seem to be quantity of data. There are multitudes of studies on how different foods affect health. The problem is that much of this information is of relatively low quality² and tends to be in the form of links between specific nutrients and disease. For example, we learned in the 1920's that iodine deficiency can lead to thyroid problems (this is the reason salt is often fortified with iodine, although no longer deemed necessary for those eating a well-balanced diet). However, we do not actually have a good handle on how broad classes of food affect us over a lifetime. This is the result of several challenges:





Logistical hurdles: In an ideal nutrition study, researchers would be able to either completely control or accurately observe what people eat over a long period of time. The reality is that this kind of direct measurement is not possible when studying a large and diverse population sample that is needed to produce valid study results.

The most common method of data gathering is using questionnaires to ask people what they have eaten. Unfortunately, this self-reported data can be quite unreliable, as people frequently forget, underestimate, overestimate, or even lie about their food intake. It is also both impractical and inaccurate to require study groups to follow a strict diet for a long period of time, as most people cannot or will not adhere to this level of rigor.

Funding issues: Compared to other medical fields, nutrition science receives little government funding. As a result, nutrition scientists often accept funding from large food companies, which holds the potential to introduce bias into both which studies are conducted, as well as into the results they report. In a recent piece for *The BMJ*, a peer-reviewed journal published by the British Medical Association, Tim Spector, Professor of Genetic Epidemiology at King's College London, and Christopher Gardner, Professor of Medicine and Director of Nutrition Studies at the Stanford Prevention Research Center call for greater transparency of funding sources and more rigorous publishing practices.¹

The focus of dietary measurement: Certain characteristics of food, such as macro- and micro-nutrient content and calorie quantities, have been the primary focus of much nutrition research. This may be because they are relatively easy to quantify in practice and not because they are necessarily the best measures of how food impacts the human body. Moreover, these characteristics lack the context to paint a complete picture of the complex food choices people make and the effects these choices have on our health. As an alternative, Spector and Gardner support moving toward studying food patterns.¹

One new approach: Diet ID

The reality is that most foods contain a combination of nutrients, and people eat a variety of different foods. A new research movement is emerging that emphasizes studying food patterns, as opposed to treating macronutrients (e.g., fat, carbohydrates, protein) and micronutrients (e.g., individual vitamins and minerals) as individual components to be controlled. A person's food pattern is defined by the quantity, variety, and combination of different foods and beverages in their diet and the frequency with which they are habitually consumed.

In an effort to begin tracking these patterns, scientists have created a tool called **Diet ID**. The project is led by Dr. David Katz, the founding director of the Yale-Griffin Prevention Research Center; Christopher Gardner was the lead scientist on the development team. Diet ID is a novel method for assessing an individual's diet. It leads the user through a series of picture comparisons of food (Figure 1), until it can identify an approximation of the general type of diet the user eats.

This method was inspired by an optometry machine – the “phoropter” – that allows a patient to flip through different lenses until they find the one through which they see the sharpest image. The idea is not to get a complete list of the exact foods someone eats at every meal, but rather to identify the picture that most closely indicates the overall diet trend for the individual.

This type of trend information can be used by researchers to assess the diet patterns of study participants more holistically. Katz and his team are working to establish Diet ID as more accurate and efficient than existing measures of diet, and early tests have been positive in this regard.³ Diet ID is currently available to organizations interested in helping their clients/participants improve their nutrition intake, including health clinics, employers, and researchers.



Figure 1. An example of the picture comparisons shown to users of Diet ID

A plant-based diet

There are a growing number of diet choices that promote healthier eating. Common among several of the most-well known diets (e.g., paleo, Mediterranean, vegan), is an emphasis on the consumption of plant-based foods (sometimes alongside animal protein, sometimes without), and the avoidance of added sugar, refined grains, and ultra-processed foods. There is increasing evidence that consuming more plant-based foods is beneficial to our overall health, especially our immune system health. There are also data indicating that consuming more plant protein than animal protein is healthy for both ourselves and the environment.

The microbiome, diet, and immune health



One of the most recent and important additions to nutrition science is the study of the gut microbiome. The microbiome is the community of microbes that inhabit our bodies. The particularly robust community in the large intestine is known as the gut microbiome. A healthy gut microbiome has shown a strong correlation to a strong immune system. Unhealthy gut bacteria can lead to an increased risk for developing autoimmune diseases or cancer, with some chemicals from the microbiota triggering inflammation, which is itself associated with poor health outcomes. Diversity in the microbiome, that is, having a lot of different types of good bacteria present, is associated with greater gut biota health and reduced inflammation. This diversity is achieved through diet.

The food we eat has a direct effect on the composition and health of our gut biota. This has been the focus of the work of Justin Sonnenburg, Associate Professor of Microbiology and Immunology, and Erica Sonnenburg, Senior Research Scientist in the Department of Microbiology and Immunology, both at Stanford University. In particular, the “Western” diet that is commonly consumed in the United States is associated with reduced diversity in the microbiome and higher rates of inflammation, as compared with more “traditional” microbiomes which can still be found in some tribes such as the Hadza in Tanzania. These trends are detailed in their book, *The Good Gut: Taking Control of Your Weight, Your Mood, and Your Long-Term Health*.⁴

A key difference seems to be that the Western diet is higher in processed foods and lower in plant-based foods, and more specifically, fiber. Fiber consumption is critical in promoting diversity in the microbiome. In the absence of adequate fiber, the gut biota can turn to using the gut barrier itself for fuel, which leads to a thinning of the gut lining, making it more susceptible to inflammatory agents. A recent study by researchers at Stanford, including the Sonnenburg Lab, also pointed to the benefits of

fermented foods, which were found to be associated with decreases in many inflammatory markers and increases in microbiota diversity.⁵ This is an ongoing area of study, and we can expect to see more findings in the coming years about how the foods we eat affect our gut and immune health.

Dietary fiber and fermented foods are each uniquely beneficial to gut microbiome health.

Such findings about the relationships between foods and gut health will also help advance the field of Precision Nutrition, a component of Precision Lifestyle Medicine, an emerging field related to advances in human genome sequencing. Precision Nutrition aims to account for differences between individuals' metabolisms based on factors such as genetic makeup, age, lifestyle, and health status in order to make individual dietary recommendations that will prevent disease.⁶ The development of gut microbiota profiling allows scientists to examine the composition and quantity of microbes present in the gut. As scientists gain a greater understanding of how certain foods affect the gut biota, they may be able to partner an individual's gut microbial profile with their genetic background to make specific dietary recommendations to prevent disease.

Plant-based protein

In a 2019 article for *Nutrition Reviews*, Christopher Gardner and his colleagues make the case that Americans consume more animal protein than is necessary for maintaining a healthy diet.⁷ The authors do not suggest that Americans should necessarily give up all animal products. They instead make three key points in support of reducing animal protein and increasing plant-based food consumption:

1. Many adults are consuming more protein than is necessary (especially given that our bodies cannot store excess protein).

The researchers used three approaches to estimate how much protein Americans consume per day. The average of these estimates came to 90-100 grams/day, 70-85% of which is animal protein. For an average adult, the Recommended Dietary Allowance (RDA)* for protein is 0.8 g/kg of body weight. This means that for a 175 lb. adult (about 79 kg), their RDA is 63 grams of protein per day, well below average consumption. Any excess protein consumed is converted by the body into carbohydrate and fat. This estimate is only an average – protein needs vary based on a number of characteristics such as sex, age, and lifestyle (e.g., children, pregnant women, and athletes typically need a little more).



2. It is possible to get sufficient protein from plants, along with all necessary amino acids (Figure 2).

Amino acids are organic compounds that combine to form *proteins*. It is commonly believed that plants do not supply certain amino acids, while all can be found in animal protein. This in fact is untrue; the proteins in plant foods contain all 20 amino acids.

*The Recommended Dietary Allowance (RDA) is one of the Dietary Reference Intakes (DRIs) used by the U.S. Department of Health and Human Services for dietary recommendations and assessment. The RDA is the Estimated Average Requirement (EAR) plus two standard deviations to provide a safety buffer in meeting the nutrition requirements of the majority of the population – in other words, meeting the RDA level of nutrients for an individual likely means exceeding the requirement for the majority of individuals, for the sake of providing adequate intake for those individuals at the highest end of the range of individual requirements.

The key to understanding protein quality is to understand that it is the proportions of amino acids that are most important. The amino acid present in the lowest proportion relative to its daily requirement is known as the “limiting amino acid.” For a plant-based diet, the most common limiting amino acids are lysine (which is most limited in grains) and methionine (which is most limited in beans). Because grains and beans have different limiting amino acids, they are considered “complementary” proteins, that when combined, provide all needed amino acids in the appropriate proportions.

The idea of complementary proteins is somewhat antiquated in an environment where there is access to a variety of healthy foods, and there is no clear time frame in which both components must be consumed to be complimentary. Researchers suggest that consuming complementary proteins over the course of a day as part of a well-balanced, diverse diet should be sufficient for most healthy adults.⁸

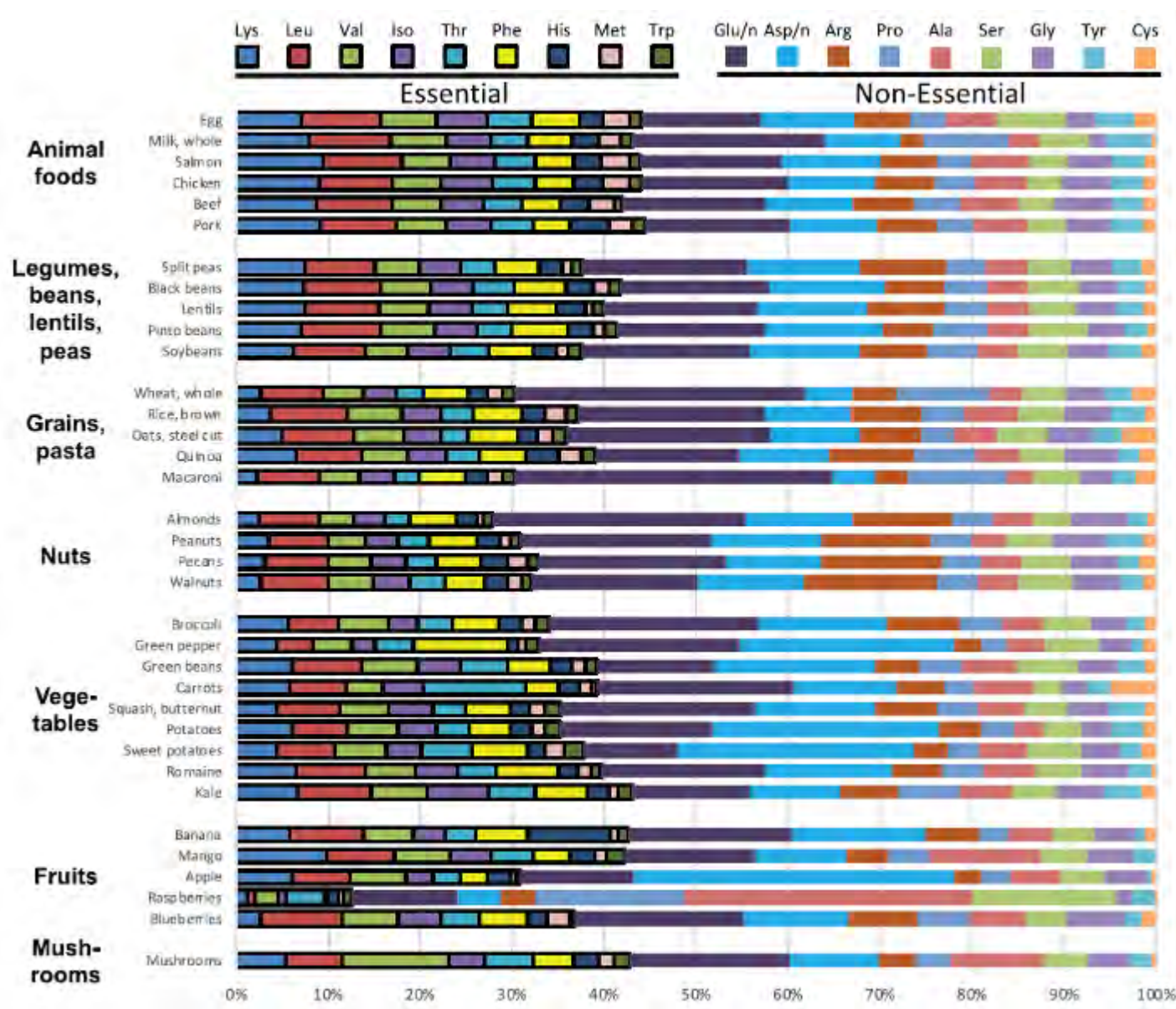


Figure 2. Proportions of amino acids in selected foods across food groups.⁷ All plant foods contain all 20 amino acids. “Essential” amino acids must be obtained through diet, while “non-essential” amino acids can be produced by the body and so typically do not need to come from our diet.

3. Reducing meat consumption is beneficial to the environment.

Producing animal protein – especially under “industrial” conditions – requires considerable environmental resources, leaving large carbon and water footprints. Beef products in particular affect the environment, making up approximately 70% of the carbon footprint attributable to protein production in the U.S., while plant proteins only contribute to 4% of our carbon footprint.

With water it’s a bit more complicated. Beef products currently make up 58% of the overall water footprint, while plants make up 23% of our overall water footprint. However, plants would eventually use up more water in their production than animals – that is, if all animal protein were replaced with plant protein, our overall water usage would actually increase. Gardner and colleagues suggest that a shift to producing a higher proportion of protein through plants, which would significantly reduce carbon emissions, be coupled with a reduction of our excess protein intake (as covered in the first point in this section), which would lower the overall water footprint.

Beyond the benefit to the climate, the relationship between diet and the environment can also be used to motivate healthier eating habits. In the Stanford undergraduate class “Food and Society”, students engaged with books, films, and other materials that highlighted issues related to food production such as the environment, agricultural practices, and social justice.⁹ The teaching team found that the students engaging with these materials were more likely to improve their diet and were especially likely to increase their vegetable consumption as compared with students who took an alternate health-related human biology course.

The key motivators for these students varied quite a bit; some were more motivated by the environmental impacts of their dietary choices, while others were more likely to change based on what they learned about animal rights and welfare or the working conditions of farm workers. These findings indicate that such external motivators may be effective in improving the diet of those who are not motivated to eat healthfully for their own sake.



Plant-based meat

While a majority of Americans' protein consumption currently comes from animal-based meat, supporters of more heavily plant-based diets are looking for ways to change this for reasons of both personal and environmental health. This may be easier to do if an approach can be found that does not ask people to make significant changes in their eating habits.

To this end, a group of Stanford University scientists have devoted themselves to developing food that perfectly mimics animal-based meat but that is made from plants. Professor Emeritus of Biochemistry Pat Brown is the Founder of Impossible Foods, and Professor of Structural Biology Jody Puglisi serves as the lead scientific advisor for Beyond Meat, a competitor in the space. Both companies envision a food that appeals to meat-lovers, reduces demands on the environment, and is potentially healthier for consumers of a high meat diet.

Of course, creating a near-exact replica of animal meat using entirely plant-based products is immensely challenging. Food has deep personal and cultural connections, and the particular experience of cooking and eating a favorite food is not easily replaceable. Scientists have had to figure out how to replicate the exact taste, smell, and feel of animal meat through a variety of methods, from using beet juice to simulate the “bleeding” that happens while cooking,¹⁰ to matching the frequency at which a burger sizzles while being cooked.



Professor Puglisi has noted that the producers of this product must not only accomplish the scientific feat of capturing the meat experience anew; they must also gain consumers' trust. This type of engineered food represents a whole new approach for nutrition science. While the ingredients are made entirely from plant products, they are developed in a way that is new to consumers and moreover new to society. Never before have food and technology been so intertwined.

Beyond Meat and Impossible Foods are part of a burgeoning field in food production, and we can expect to see both more food offerings (e.g., fish products) and further study about the health outcomes associated with consuming them.

Read about some initial findings about plant-based meat and health outcomes.

<https://med.stanford.edu/news/all-news/2020/08/plant-based-meat-versus-animal-meat.html>

Stanford resources for eating a healthier diet

Stanford Lifestyle Medicine best practices

Stanford Lifestyle Medicine, led by Stanford Center on Longevity faculty affiliates Dr. Michael Fredericson and Dr. Douglas Noordsy, has compiled a list of recommendations based on healthy dietary guidelines that advocate for a balanced eating pattern composed of a variety of nutrient-dense, minimally processed whole foods in proper portions. The recommendations can be viewed in the Data Update section of this report, as well as on the Lifestyle Medicine [website](#).



Menus of Change: The role of food providers

Americans get many meals and snacks from restaurants and in prepared form. In a 2018 report, *America's Eating Habits: Food Away from Home*,¹¹ the USDA reported that American adults acquire an average of 5 meals per week that were prepared outside the home. Dining out makes it immensely challenging to follow a healthy diet, as food prepared outside the home tends to be higher in calories while being less nutritious, containing higher levels of saturated fat and sodium and less fiber than food prepared at home.

Asking people to prepare all of their own food is not a solution. For some people, the convenience of prepared food is too important, while others enjoy the social or the cultural aspects of going out for a meal. A better solution is to help restaurants, cafeterias, and other food providers to be more intentional about offering healthy, appealing food options. This is an area of great opportunity for these businesses.¹²



The Menus of Change (MoC) initiative arose out of a long-standing collaboration between the Culinary Institute of America and the Harvard T.H. Chan School of Public Health. They saw potential for new opportunities at the intersection of nutrition science, sustainability, and the culinary arts. They believe that chefs are uniquely positioned to create the changes needed to help slow advancing rates of both chronic disease and climate change through culinary practices. A recent area of focus for MoC has been on creating a framework for menu design called “plant-forward,” which includes options for vegetarians and vegans, but is really aimed at helping “flexitarians” and omnivores reduce their meat consumption without necessarily eliminating it completely.

The Menus of Change findings and recommendations are largely aimed at chefs and restaurants. MoC provides many resources for chefs and business owners who wish to make changes in their offerings, such as their **24 principles** of healthy, sustainable menus. MoC is also involved with university campus dining representatives and faculty, with whom they have formed the Menus of Change University Research Collaborative, jointly led by the Culinary Institute of America and Stanford University. The universities involved have implemented MoC principles in their campus dining facilities, and some use those facilities as “living laboratories” to find ways to encourage students to eat healthier diets.*

Stanford researchers, including Alia Crum, Assistant Professor of Psychology, and Brad Turnwald, Postdoctoral Research Fellow in Psychology, observed that, in response to rising rates of obesity, restaurants and other dining establishments were incorporating more healthy menu items. However, these dishes were often given names or labels that touted their health benefits, which actually discouraged people from eating these foods because they were perceived as less appetizing.¹³ Teaming with researchers at four other universities, the Stanford team created the Delicious Impressions Support Healthy Eating (DISH) study, which aimed to test whether taste-focused labels would more successfully encourage students to eat vegetables than health-focused labels.¹⁴



Asparagus	Ultimate Chargrilled Asparagus
Beets	Dynamite Chili and Tangy Lime-seasoned Beets
Brussels Sprouts	Tender Caramelized Brussels Sprouts With Olive Oil Drizzle
Carrots	Twisted Citrus-glazed Carrots
Cauliflower	Zesty Buffalo-garlic Cauliflower Bites
Corn	Salt n' Pepper Oven-roasted Corn on the Cob
Eggplant	Shanghai-spiced Glazed Eggplant
Green Beans	Sweet Sizzlin' Green Beans and Crispy Shallots
Peas	Tavern-style Sizzlin' Sweet Peas
Sweet Potatoes	Zesty Ginger-turmeric Sweet Potatoes
Turnips	Herb n' Honey Balsamic-glazed Turnips
Zucchini	Slow-roasted Caramelized Zucchini Bites

Figure 3. Examples of edgy descriptions from the *Edgy Veggies* toolkit from SPARQtools.

*This effort at Stanford was led by Senior Associate Vice Provost of Residential & Dining Enterprises (R&DE), Shirley Everett, and Executive Director of R&DE Stanford Dining, Eric Montell. Read about how they applied Menus of Change principles to a new Stanford dining facility: <https://www.menusofchange.org/case-studies/stanford>

The dining facilities in the study created a repeating rotation of vegetables over the course of 3-5 weeks, for which they could change the label each time a vegetable was offered. For example, prepared green beans were called “Sizzlin’ Szechuan Green Beans with Toasted Garlic” under the taste-focused label, “Nutritious Green Beans” under the health-focused label, and just “Green Beans” under a basic label as a control condition. Importantly, the green beans were prepared the same way each time, and the labels, particularly the taste-focused label, were ensured to be accurately descriptive. The researchers found that, across all five universities, the taste-focused labelled vegetables were selected 29% more often than health-focused labelled vegetables, and 14% more than the vegetables with a basic label.

The researchers have created an online toolkit, called “**Edgy Veggies**” for learning how to craft taste-focused labels, particularly by using exciting or indulgent words, or words evocative of a tradition or location (Figure 3). This toolkit is useful for professionals or non-professionals (e.g., parents) who prepare food for others.



Food providers are not the only institutions that can play a role in helping Americans eat a healthier diet.

Hollywood can play a role here too. Stanford researchers found that popular movies typically depict food that is not at all in line with federal recommendations. While the movies are often depicting what is “normal” for Americans, they are also perpetuating the idea that eating these rich and indulgent foods is acceptable. Filmmakers have an opportunity to, when unhealthy food is not essential to plot, help shift our norms by portraying healthier food onscreen.

Read more:
<https://news.stanford.edu/2020/11/23/popular-american-movies-depict-unhealthy-diet/>

Data Focus: Income, Education, and Diet

In order to assess how many Americans are eating a healthy diet, the Stanford Center on Longevity’s Sightlines project uses data from the nationally representative Behavioral Risk Factor Surveillance System (BRFSS), administered by the Centers for Disease Control, which gathers information about Americans’ eating habits. Because there is no *one* correct way to eat a healthy diet, it was necessary to choose a measure that would be considered integral to health for most people. As discussed in the inaugural 2016 Sightlines report and throughout this report, eating sufficient plant-based foods is generally recognized as being correlated to positive health outcomes. Eating more plant-based foods also implies eating less highly processed food, which is generally viewed as unhealthy. Based on this, the Sightlines team selected eating at least 5 servings of vegetables and fruits on a daily basis as its core measurement.

As evidenced in the Data Update section of this report, few Americans are eating 5 servings of vegetables and fruits daily, with a slight negative trend over time. One other notable persistent trend is that people with higher incomes and people with a higher level of education (particularly people who are college educated) are more likely to get their 5 servings than their less educated and lower income peers.

This “nutritional inequality,” or the disparity in nutritional quality from food consumption based on income, is well-documented in the United States.^{15,16} Many researchers and policymakers have pointed toward “food deserts”, or a scarcity of supermarkets selling healthy, fresh foods, as a potential culprit for this inequality. The USDA reported in their 2015 Food Access Research Atlas¹⁷ that 19 million people, or 6.2% of the American population, were living in low-income neighborhoods at least 1 mile away from a supermarket (or 10 miles away for rural areas). The argument is that if people do not have ready access to fresh foods, then they have no choice but to consume the unhealthy, highly processed alternatives available to them. Living in a food desert is separate from, but often occurs alongside, food insecurity, which is when a person or family runs out of food or money for food.

Researchers are finding that the issue of food availability may not be the (only) key to alleviating nutritional inequality. One study noted that many grocery stores that were placed into areas previously identified as food deserts were failing.¹⁸ Upon further inspection, they found that it was commercial- and government-driven markets that were failing at higher rates, while nonprofit stores that fostered community engagement and cooperative management were successful.

Additionally, even if a grocery store stays open in a former food desert, it may not be that the clientele buys healthier food. In a 2019 study, a team of economists used a combination of national surveys about grocery store sales and American purchasing habits to look at the grocery purchases of people living in food desert neighborhoods that had recently acquired a grocery store.¹⁹ They found that, while people did indeed start shopping at the new stores, they were not buying healthier food. The researchers suggest that education may play a more important role in healthy food choices than cost or convenience. This includes both the general education level of the individual and nutrition-related knowledge.



Socioeconomic status in and of itself can also influence the way people view food and make food choices. While at Stanford, sociologist Priya Fielding-Singh found that parents of low socioeconomic status viewed unhealthy food as an attainable treat for their children when they may not have been able to afford other items of material desire.²⁰ Families of high socioeconomic status, on the other hand, could generally afford more material things, and thus restrict food to what is “right” and healthy. It was not that low-SES parents undervalued or did not understand healthy diets, but their desire to provide for their children in the face of their financial constraint was also very important. Fielding-Singh suggests that alleviating poverty and helping people attain financial security would help them to be able to provide other material goods instead of unhealthy foods.

Most Americans are not eating their five servings of fruits and vegetables per day, and the number decreases with lower income and education. Ensuring that people have proximal access to healthy, fresh foods, which has been identified as an issue in many low-income neighborhoods, is a necessary part of the equation for reducing nutritional inequality, but the findings indicate that access alone is not sufficient to improve eating habits. Many other factors such as community involvement, nutritional education, and financial security affect both access to and likelihood of consuming healthy food.

There are several other steps we can take as a society to help everyone eat more vegetables and fruits, such as by encouraging food providers to offer more healthy options and use taste-focused labelling, and using a plethora of motivators that target not just health but also environmental issues. Shifting current dietary practices so that they better align with both human health and the health of the planet will enhance the joy that food can bring and the opportunity of century-long lives.



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