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Scientifically-Supported Links Between Cooking and Well-being

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nature
research intelligence

February 2024

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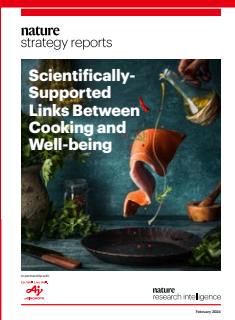
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ABOUT THIS REPORT

This Nature Strategy Report was produced for Ajinomoto by Nature Research Intelligence & Nature Research Custom Media, part of Springer Nature.

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Ajinomoto contracted Nature Research Intelligence to complete this Nature Strategy Report to understand the effect of cooking on well-being. Here is a summary of the contents:

- The report looks at the relationship between dietary choices, cooking habits, and well-being in terms of physical health outcomes. The text suggests that home cooking is linked to consuming more whole foods, which have the healthiest nutritional profile of the NOVA processed food categories (see page 7-8). The report suggests that ultra-processed foods are the second healthiest category, while processed foods are the least healthy. However, many studies show adverse health effects linked to diets high in ultra-processed foods, which also tend to be low in whole foods. These include negative impacts on the gut microbiome, as well as increased inflammation and an increased risk of overall mortality. One reason that diets high in ultra-processed foods may be less healthy is that — due to relatively low levels of protein in these foods — people may be compelled to eat more of them in order to reach required levels of protein, resulting in overconsumption of fats and carbohydrates. Ultimately, the report underscores the significance of home cooking as common vehicle for more nutrient-rich diets, which are better for physical health and well-being.
- The relationship between nutrient-dense diets and mental well-being has also been explored. The findings reveal a complex picture in which mental health and psychological stress impact diet and vice versa. Nonetheless, the report delves into the positive impact of specific nutrients on the outcomes for brain-related disorders, mood and cognitive function, highlighting the important role of reduced inflammation. Diets high in protein are also linked to stronger cognitive function. In addition, the report touches upon the social and emotional benefits of communal eating and the potential implications of home cooking on family dynamics and well-being, emphasizing the need for further research in this area. If, as the first section of this report suggests, home cooking is associated with diets that contain more nutrient dense whole foods, then home cooking can be feasibly linked to many aspects of mental well-being.
- The COVID-19 pandemic significantly altered eating habits worldwide, leading to increased home cooking and changes in food consumption. While some individuals embraced cooking at home and believed it improved their diets, others faced food insecurity, some even resorted to growing their own food. However, pandemic-related shifts in nutrition were complex, with some people eating more nutritious meals, while others consumed more fast food and snacks. The dietary changes driven by COVID-19 appear to have had varying impacts on health and well-being, including weight gain and potential exacerbation of certain health issues.
- Home cooking is generally associated with healthier eating habits, but its benefits depend on various factors, including ingredients and cooking skills. Encouraging cooking education and aligning the cooking practices of adults with healthy meal preparation for children can promote better nutrition from a young age. Studies also indicate a correlation between the frequency of eating home-cooked meals and the quality of diets among students. Gender roles in meal planning and preparation can influence diet quality, highlighting the need for further research to understand these dynamics. Overall, home cooking plays a crucial role in improving well-being across different demographic groups.
- Government initiatives worldwide aim to improve consumer awareness of food content and its nutritional value through various labeling methods, such as front-of-pack labeling (FOPL). These initiatives impact dietary choices, nutrient intake, and food industry practices. However, the effectiveness of labeling approaches varies, and their impact is influenced by factors including taste preferences, socioeconomic

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status and regional differences. Reducing sodium consumption is a global health goal, with countries implementing strategies such as FOPL and behaviour change campaigns. The effectiveness of these measures depends on factors such as GDP and cultural attitudes towards salt. Case studies from Japan and Mexico highlight the complexities of addressing sodium intake and obesity through government policies, emphasizing the need for multifaceted approaches.

- A poor diet is a leading cause of non-communicable diseases, surpassing other modifiable factors, such as smoking and alcohol consumption. However, defining the ideal diet remains challenging due to reliance on observational studies and self-reported data. A balanced diet should have a focus on high-quality carbohydrates,

lean animal proteins, and unsaturated fats, while limiting trans fats. The positive well-being outcomes of the Mediterranean diet is well-supported by evidence. Other diets with some supporting evidence, such as keto, plant-based, and carnivore diets, show potential benefits with caveats, highlighting the complexity of dietary choices and their health implications.

- Taste plays a significant role in well-being, impacting mood, cognition and dietary choices. Loss of taste, as seen in some people infected with COVID-19, can lead to diminished quality of life. Neuroscience research has revealed possible links between the loss of taste and physical changes related to a loss of cognitive function in the brain. Taste's impact on hormones, neurotransmitters,

and the gut-brain axis contribute to food consumption choices and subsequent physical health indicators. Dopamine links taste to well-being factors, such as mood and reward. Taste sensitivities also influence physical well-being. Low fat taste sensitivity is linked with higher BMI and related diseases. High salt-taste recognition is also linked to an increase in salt intake and a higher risk of heart disease (which might be addressed by replacing a desire for salt with umami flavours). Taste also provides some information about nutrient content, but the relationship is complex. Some cooking methods can increase flavour and digestibility, but also occasionally increase toxic elements in the food. So, while some connections between taste and well-being are evident, the links between cooking, taste and well-being aren't clear cut.

- Further research is needed to understand the contextualized effects of home cooking, the behavioural and psychological factors influencing cooking habits, the impact of local food environments, and the relationship between psychological factors, inflammation, and dietary choices. Additionally, exploring the long-term health outcomes of pandemic-related dietary changes, gender disparities in cooking responsibilities, and the influence of umami perception on salt reduction strategies are important areas to study.



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A note on looking at well-being

The study of well-being is a complex and evolving field. One of the biggest challenges is that there is no agreed upon definition of well-being, and definitions vary widely. Well-being, for example, has been defined as physically and mentally feeling good and functioning well; the experience of positive emotions, such as contentment; having some control over one's life; having a sense of purpose; and experiencing positive relationships, among other definitions¹.

There is also a lot of debate about widely or internationally applicable measures of 'subjective well-being' — which is how individuals evaluate or appraise their own lives as positive or negative^{2,3}. In the Organization for Economic Co-operation and Development's 2013 guidelines on measuring subjective well-being⁴, for example, the authors highlighted a need for large datasets, more standardization, and for the inclusion of objective measurements. This, they state, is to balance the cultural and linguistic variances that make it difficult to broadly compare the results derived from subjective well-being measurement tools. And while some countries have attempted to look at their broader population's subjective well-being, policy outcomes have still typically been driven by a combination of subjective and more objective data⁵.

In this report, we were asked to take a broad look at cooking and well-being, and to synthesize the most robust literature. Thus, we drew from a broad base of well-being

language to build our datasets, using keywords related to subjective well-being, as well as keywords used to look at well-being from a biological perspective (see 'Methods' on page 53).

As the aim of this report was to inform Ajinomoto of the academic links between cooking and well-being with an eye to potential implications on the international stage, we focused much of our literature review on large-cohort studies and meta-analyses.

Due to the issues we have outlined, we incorporated some studies that measured subjective well-being, but also sought out, where possible, supporting studies that use bioindicators.

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The impact of cooking on physical health



Key highlights

- Studies involving both small and large cohorts suggest people who frequently cook or prepare their meals at home tend to consume more nutrient-dense whole foods, such as fruits and vegetables, while consuming fewer processed and ultra-processed items.
- A high frequency of home-cooked meals has been linked to longevity.
- Consumption of ultra-processed food is linked to higher body mass index and waist circumference, as well as higher rates of obesity, hypertension, metabolic syndrome, dyslipidemia, asthma, functional gastrointestinal disorders and cancers.
- Processed foods may offer a lower ratio of nutrients to caloric content than whole and ultra-processed foods. But the health implications of this are unclear since diets high in processed foods contain more whole foods.

Consumption of whole, processed and ultra-processed foods

Nutrient-dense foods provide high levels of essential nutrients (such as vitamins, minerals, protein and fibre) relative to their calorie content, and their consumption is associated with health and longevity¹.

However, the role nutrient-dense foods play in home-cooked or prepared food is complex (see 'Descriptions' at the end of this section for definitions of food terms). A higher frequency of cooking and preparing food at home has been associated with consuming more nutrient-dense whole foods in studies of large cohorts in the United States, Australia and United Kingdom²⁻⁵.

Many of these studies also found that a higher frequency of cooking and preparing food at home is associated with consuming less fast and processed foods.

For example, a survey of 2,174 people in the UK between 2008–2012 revealed that processed and ultra-processed foods

generally have lower nutritional densities than unprocessed or minimally processed foods. Unprocessed or minimally processed foods were also found to be highest in protein and lowest in energy density, sodium, fat, saturated fat, carbohydrates and free sugars. Processed ingredients were highest in energy density, fat, saturated fat and free sugars and lowest in fibre and protein. Ultra-processed food products were highest in sugars, fibre and carbohydrates⁴.

Not surprisingly, minimally processed foods and diets high in these foods had the highest ratios of nutrients to caloric intake. Ultra-processed foods had the second highest ratio of nutrients to caloric intake, but diets high in them were the least healthy due to a lack of whole foods consumed. Processed foods had the lowest ratio of nutrients to caloric intake, but diets high in these foods were found to contain more whole foods than diets high in ultra-processed food, painting a complex picture⁶.

However, far fewer studies have been published on processed foods; of 23,998 studies on cooking and well-being (from the past seven years canvassed for this report), only 143 mentioned processed foods in their titles, while 399 mentioned ultra-processed foods in their titles.

Interestingly, some studies show that for certain specific groups — such as women in midlife in the US⁷ or populations in lockdown during the pandemic⁸ — home food preparation is associated with the consumption of less nutrient-dense foods that are lower in fibre and higher in fat, saturated fat, sugar, and salt, and could potentially be detrimental to health^{9,10}.

Nonetheless, numerous studies of large cohorts, ranging from the elderly in Taiwan and children in Japan to health-care professionals in the US, suggest that a higher frequency of home cooking or preparation of food is associated with

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higher intakes of whole foods and health benefits¹¹⁻¹⁵.

A 2017 study of 11,396 adults in the UK, for example, found that consuming home-cooked meals was more frequently associated with indicators of a healthy diet, such as a higher Mediterranean Diet Score, a better Dietary Approaches to Stop Hypertension score¹⁶, as well as higher vitamin C, and fruit and vegetable intakes¹⁴. A higher frequency of consuming home cooking was also associated with markers of improved cardio-metabolic health, including lower risk cholesterol ratios, normal range body mass indexes (BMIs), a lower percentage of body fat and a lower risk of developing diabetes (by HbA1c level) in a 2011 study of 15,798 people from ten European countries (Denmark, France, Germany, Greece, Italy, the Netherlands, Norway, Spain, Sweden and the UK)¹⁵.

Meanwhile, cross-sectional and longitudinal investigations in the US, Brazil, France and Spain have established a correlation between increased consumption of ultra-processed foods and adverse health outcomes. These include higher BMIs, being overweight or obese, larger waist circumference, hypertension, metabolic syndrome, dyslipidemias, asthma, wheezing, gastrointestinal disorders and cancer, including breast cancer¹⁷⁻²⁸.

Another essential aspect to consider is the gut microbiome. A 2018 study revealed that diets high in ultra-processed foods and low in whole foods negatively affect the diversity and composition of gut microbiota²⁹. This imbalance can lead to health issues, including inflammation and dysregulation of the immune system³⁰.

Indeed, a 2019 study of 19,899 Spanish university graduates linked a diet high in ultra-processed food with higher overall mortality rates³¹. Participants in the highest 25% of ultra-processed food


consumption had a 62% higher risk of all-cause mortality compared to those in the lowest.

The protein principal

Differing ratios of protein to calories are likely key to some of these findings. A recent year-long study of 9,341 Australians suggests that the preference for highly processed foods that are low in protein contributes significantly to rising obesity rates in the Western world³². The study supports the 'protein leverage hypothesis', which states that people tend to overeat fats and carbohydrates due to a strong appetite for protein. Thus, individuals whose diets are dominated by energy-dense processed foods that are lower in protein are driven to consume more calories to satisfy their protein demands, leading to health risks.

Studies of national dietary intake surveys and generic food composition databases support this notion in Canada, the US, Brazil, France, and the UK³²⁻³⁷. Each of these evaluations demonstrates that diets rich in ultra-processed foods exhibit higher levels of total fat, saturated fat, carbohydrate, sodium and added sugars, while being deficient in protein, fibre and various essential micro-nutrients.

In summary, the relationship between home-cooking habits and health is multifaceted, but associations with higher nutrient-dense food intake likely provides consumers with more nutrients relative to calorie content. Home cooking also appears to reduce the intake of ultra-processed and processed foods. As mentioned, diets high in ultra-processed foods tend to skew towards high levels of fats, carbohydrates and sugars and low protein content, which may contribute to overeating, obesity and disrupted gut microbiota. The impact of processed foods is not so clear, as their

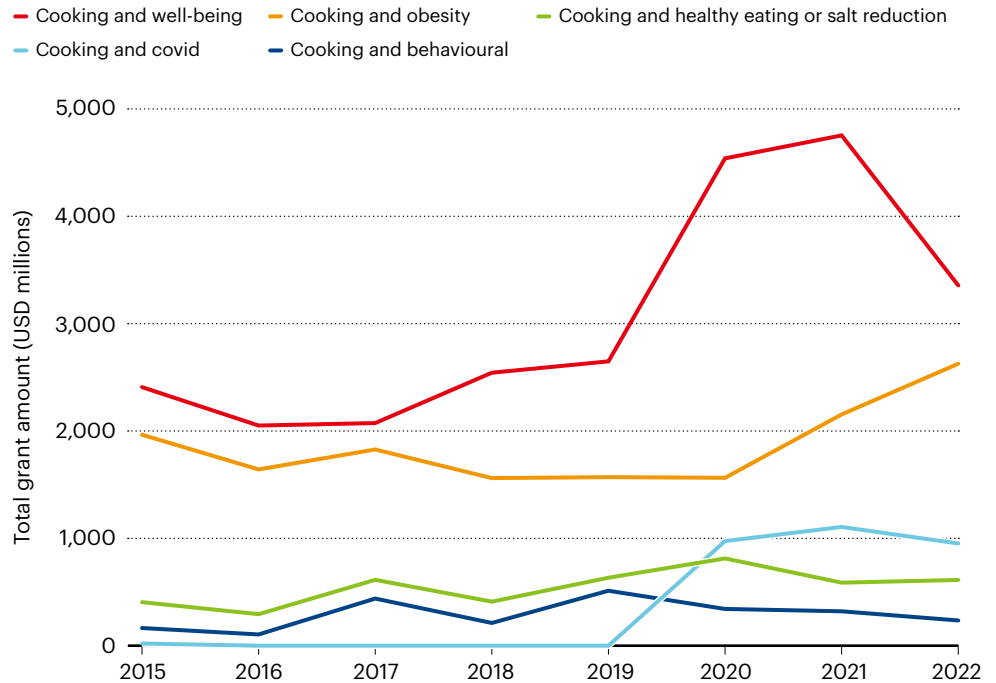


Home cooking appears to reduce the intake of ultra-processed and processed foods.

Figure 1.1

Where is the funding going?

Analysis of papers from 2015–2022 and their associated funding showed strong growth in well-funded papers on ‘cooking and well-being’ and ‘cooking and obesity’. However, there has only been slight growth in generously funded projects on ‘cooking and healthy eating/salt reduction’ and ‘cooking and behaviour’, with the topic of COVID-19 overtaking both since 2020. This suggests perhaps an increased focus on the holistic study of home cooking, but with funding leaning toward obesity over salt reduction.



health impact may be somewhat offset by the consumption of whole foods in a dietary context. Collectively, the evidence underscores the importance of prioritizing nutrient-rich foods and the potential benefits of eating more of these in home-cooked diets, if calorie consumption is controlled.

Definitions

NOVA classification system

We have referred to the NOVA classification system, as it is by far the most common system used to categorize foods based on the extent and purpose of their processing in studies on diet quality, health outcome and public health³⁸. NOVA was developed by researchers at the University of São Paulo in Brazil. It classifies foods as follows:

Whole foods

Nutrient-rich, unprocessed or minimally processed foods that are close to their

natural state and retain their original nutritional composition. These foods typically undergo minimal refinement, preserving their inherent vitamins, minerals, fibre and phytochemicals.

Unprocessed and minimally processed foods

This group includes foods that undergo minimal physical processing to preserve them, make them more accessible, and improve safety and palatability. Examples of processing include cleaning, portioning, drying, chilling, freezing, pasteurization, fermentation, fat reduction, vacuum and gas packing, and simple wrapping. Foods in this group are typically whole fresh foods like fruits, vegetables, grains, legumes, nuts, fresh meat and milk.

Processed culinary or food industry ingredients

This group includes substances that are extracted and purified from unprocessed or minimally processed foods to create culinary or food industry ingredients.

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Processes used involve physical and chemical techniques such as pressure, refining, hydrogenation, hydrolysis and the use of enzymes and additives. These ingredients are used in the preparation and cooking of dishes made from fresh or minimally processed foods and are also used in the production of ultra-processed products. Examples include vegetable oils, sugar, flours, salt, sweeteners, milk and soy proteins.

Ultra-processed food products

This group consists of ready-to-eat or ready-to-heat food products that undergo significant processing, combining multiple foodstuffs and often include additives. Processes used in production include salting, sugaring, baking, frying, canning, and the addition of preservatives, synthetic vitamins, minerals and cosmetic additives. These products are designed to be convenient, attractive, palatable and have a long shelf life. Examples include fast foods, snacks, soft drinks, candies, pastries, processed meats, frozen dishes and other convenience products.

Processed culinary ingredients

This category includes food ingredients used in kitchens to prepare and season foods. They are typically not eaten on their own but are used to prepare other foods. They are derived from minimally processed foods by processes such as pressing, refining, grinding, or milling. Examples include vegetable and nut oils, vinegar, sugar, salt and honey, without added flavours or stabilizers.

A note on the NOVA classification system

Many foods have been shown to be categorised differently across studies using NOVA classifications, with some research suggesting that NOVA criteria do not currently allow foods to be unequivocally

defined as ultra-processed³⁹. Other systems may be more fine-grained. The International Food Information Council's system, for example, contains classifications, such as: 'foods processed for preservation' (e.g. canned and frozen vegetables, fruits and soups) and 'mixtures of combined ingredients' (e.g. breads, cheese, condiments and margarine)⁴⁰.

Home-cooked or prepared

The exact definition of home-cooked food may vary slightly depending on the context and the specific research study. However, the general concept revolves around the idea of preparing meals in a home kitchen using traditional cooking methods and whole or minimally processed ingredients. Some common variations and aspects that researchers consider when defining home-cooked food include:

Prepared and cooked at home

This is the most basic definition and refers to meals or dishes that are made in a household kitchen using raw or minimally processed ingredients.

From scratch

Home-cooked food is often described as being prepared 'from scratch', meaning that it involves using basic ingredients rather than pre-made or processed components.

Cultural and regional variations

Definitions can take into account cultural variations in cooking practices and ingredients, as what constitutes 'home cooked' can differ across different cuisines.

Social and cultural aspects

Definitions can take into account the social and cultural aspects of cooking and eating, including the idea of meals prepared and shared within a family or community setting.

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The impact of cooking on mental health

Mental health

Key highlights

- Dietary nutrients have been linked to brain-related disorders, brain function and mood.
- Inflammation may play a key role in how dietary nutrients affect mental health.
- Macro-nutrients related to meat and seafood products play a prominent role in brain function.
- Eating together or 'commensality' has been linked to physical health and feelings of connection. Eating alone has been linked to unhappiness, but more robust research is needed to support findings regarding more complex links to well-being.

Nutrient dense diets' impact on mental or emotional health

In the previous section of this report, we established that home cooking and eating is linked to more nutrient-dense diets. Here, we look at the impact of nutrients and diet on mental health and wellness. We find an already well-studied relationship between nutrients and brain-related disorders or brain function, and more-complex interplays with mood and stress. How diets affect mental health is complex, involving lifestyle factors and interrelated mechanisms in the body.

You are what you eat?

Some researchers have argued that access to the fatty acids of marine food sources and humans' early use of the fire for cooking were key factors in the development of our big brains and our craving for foodstuff characterized by sweet and umami flavours¹. A lack of these in prepared meals may be a factor in people having poorly managed diets and consuming excessive sugar, salt and fat².

In fact, a review study has suggested that an imbalance in the diet of modern humans away from omega-3 fatty acids and towards omega-6 fatty acids may be a reason for the rapid growth in neural and brain-related conditions, such as bipolar disorders³ and depression⁴.

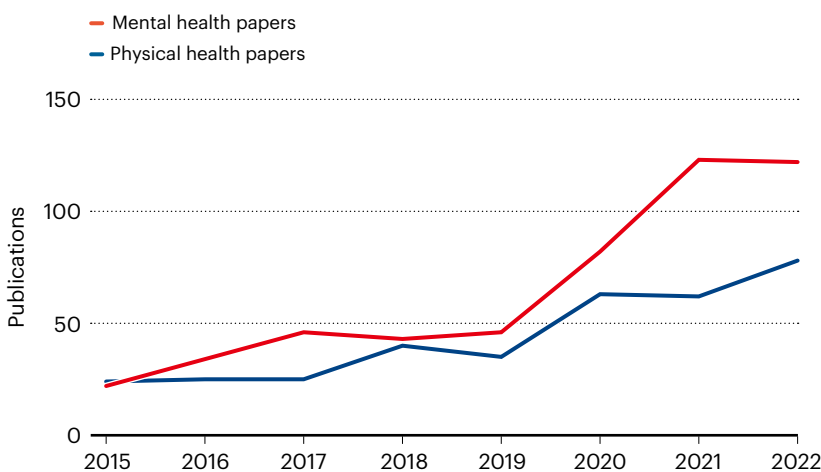
Deficiencies in some individual vitamins (including vitamins C, B6, B9, B12, D and E) have been linked to an increased risk of developing psychiatric and neurological disorders^{5,6}.

The impact of all these nutrients on inflammation is among the most compelling mechanisms linking diet and brain-related disorders. Two meta-analyses in 2016 and 2017 confirmed that major depressive disorder, bipolar disorder and schizophrenia are associated with

Figure 1.2

An acceleration in publications on cooking, well-being and mental health since 2020

Between 2015 and 2022, 352 studies in our dataset on diet and nutrition also mention physical health in their title or abstract. 518 studies from the same dataset mention mental health in the title or abstract. The numbers of published studies on both topics have increased significantly since 2019, with mental health having significantly more publications than physical health from 2020.





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toxins, and neurohormones that can alter eating behaviour and mood¹⁶. Thus, mental health also has an impact on diet.

Nutrients have also been linked to more complex aspects of emotional well-being. For example, vitamin B9 is involved in brain functions such as sleep, and has been linked to mood, and irritability¹⁷, while neonatal deficiency in vitamin B12 has been linked to anorexia, irritability, lowered brain growth, and long-lasting cognitive impairment¹⁸.

Boosting the brain: cognitive function

In terms of cognitive function, observational studies and clinical trials have shown that various single nutrients, such as B vitamins, vitamin D, polyphenols, n-3 fatty acids; food groups, such as fish/seafood and vegetables; and dietary patterns, such as the Mediterranean diet¹⁹ and Dietary Approaches to Stop Hypertension, may protect against the development of age-related cognitive decline and pathological neurodegeneration²⁰⁻²².

The mechanisms suggested by these studies include a reduction in neuroinflammation²⁰, an increase in the antioxidant defense against free radicals facilitated by dietary nutrients²¹ and a modulation of gut microbiota structure and function²².

However, a 2021 cross-sectional, population-based study of 48,749 participants in the UK found that vegetable intake, high and low fibre intakes, and milk intake were negatively associated with general cognitive ability. Fish, unprocessed red meat and nutrients were found to be positively correlated with general cognitive ability, suggesting that, as in physical health, protein and related amino acids may play an outsized role²³.

increased inflammatory markers that can be linked to diet⁷⁸. And several studies suggest dietary interventions associated with reductions in inflammation, such as the Mediterranean diet, could be effective at reducing the incidence and symptoms of psychiatric disorders⁹⁻¹³.

However, the causal impact of diet on mental health is unclear. Systematic reviews of studies on people with schizophrenia have shown a link with excessive caloric intake, a low-quality diet and poor nutritional status compared to the general population^{14,15}. But psychological stress and depression, frequent co-morbidities of schizophrenia, have also been shown to promote the consumption of highly palatable foods, which are often high in sugar, salt and saturated fats. This influences which gut bacteria thrive through stress hormones, inflammation and autonomic alterations. In turn, gut bacteria release metabolites,

There is significant evidence that micro-nutrients, such as dietary amino acids including tryptophan, methionine, and serine are essential for brain function²⁴; while glutamine, γ -aminobutyric acid and glutamate are precursors of proteins that are crucial for brain function²⁵.

Does eating communally promote wellness?


The benefits of home cooking go beyond supplying nutrient-dense diets. Sharing food, known as commensality, fosters a sense of belonging and social connectedness in places as culturally disparate as Chile and New Zealand^{26,27}. Preparing one's food can also instill a sense of control over one's diet, leading to positive feelings of accomplishment and self-efficacy²⁸. In Thailand, a cross-sectional and longitudinal study of 39,820 people showed that frequently eating main meals alone is associated with unhappiness²⁹.

In terms of health, eating home-cooked meals is linked to improved nutritional health (see the 'physical health' section). For example, a 2018 meta-analysis of family meals covering 203,706 children globally found higher family meal frequency is linked to better overall diet quality³⁰. However, a systematic review of family meals published in 2020 noted that current experimental studies were unable to fully explore the causal relationship between these meals and outcomes related to well-being³¹, due to a lack of statistically significant findings in relation to control groups³².

Other researchers note the possibilities for heightened inequalities within the household due to an increase in workload due to cooking duties, leading to lower mental and emotional well-being for some members of the family³³⁻³⁵. These studies indicate that this area needs more nuanced and robust research.

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COVID-19



The influence of **COVID-19** on cooking and well-being



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Key highlights

- The COVID-19 pandemic forced many people around the world to cook and eat at home.
- Despite a significant fall in the amount of people eating out at restaurants, many studies found a drop in levels of overall nutrition during this time.
- More time at home and declining food choices contributed to many people gaining weight during the pandemic.

The rise of home cooking during the pandemic

The COVID-19 pandemic forced most people around the world to adjust their eating habits. One study in the US showed reductions in eating at full-service and fast-food restaurants¹. At the same time, the pandemic created shortages in food supplies². As a result, many people changed what and where they ate.

One online survey of 20,554 participants from five countries (Australia, Canada, Mexico, the UK and the US) reported that 62% of the participants ate less food prepared away from home, but 11% ate more food prepared away from home³. In some countries, almost everyone ate out less. A study in Zimbabwe, for example, found that 89% and 71% of the participants ate less at restaurants and ordered less fast food, respectively⁴. Research on people in Kuwait noted “a significant increase in the percentage of participants who had their main meal freshly made”⁵. Some studies of students in China and Brazil even found that they ordered food less during the pandemic^{6,7}.

However, the data on eating home-cooked food vary considerably even when analyzing a single country. In Saudi Arabia, for example, one study reported that people eating homemade food increased from 35.6% to 85.6% during the pandemic⁸. In contrast, another study in

Saudi Arabia found that nearly half of the participants reported eating more fast food during the pandemic⁹.

Some families made cooking at home a family activity. A cross-continental study of families with children in Ireland, Great Britain, New Zealand and the US found a significant increase in the amount of time that families cooked together¹⁰.

During the COVID-19 pandemic, many people faced food insecurity, which is not having access to sufficient or adequate quality food to meet basic needs. More than half of the people polled for a study from Cameroon lacked sufficient food¹¹. Even some of the world’s most economically powerful countries experienced pandemic-driven increases in food insecurity. For example, one study noted that in the US, “household food insecurity increased from 11% in 2018 to 38% in March 2020”¹². Moreover, a study of people in the US reported that those with lower food security were more likely to prepare food at home¹³.

To combat food insecurity, some people even found more ways to produce their own food. Even before the pandemic, many low-income families in the US practiced home food procurement such as gardening, and one study found that some methods of food procurement increased during the pandemic and that this approach “may be an important safety net for food insecure households”¹⁴.

Working from home during the pandemic also impacted time spent cooking. One study noted that “among individuals with a spouse or partner present, those who worked from home spent 25 more minutes engaged in food production and 48 more minutes eating and drinking at home than did individuals who worked away from home, which are large relative to the sample averages of 33 and 31 minutes, respectively”¹⁵.

Pandemic-related changes in nutrition: healthy or not?

The idea that home-cooked diets are more nutrient dense (discussed in the ‘physical health’ section) may explain why some people who spent more time home cooking during the pandemic believed that they ate more nutritious meals¹⁶. In a study from Brazil, for example, people who spent more time cooking believed it improved their diets¹⁷.

But even when cooking at home, food insecurity can impact the quality of the food that a family can obtain. For example, one report pointed out that: “Food insecure households were significantly more likely to agree they were consuming less fresh food compared with food secure households”¹⁸. Available or not, the pandemic raised the interest of many people in seeking higher quality food both at restaurants and at home^{19,20}. Nonetheless, some research found that when people ate at restaurants during the pandemic, they ordered higher calorie meals²¹.

When people did opt to cook more at home during the pandemic, the impact did not necessarily improve their overall nutrition. Various studies found that people ate more junk food and snacks at home during the pandemic than they had before it²²⁻²⁴. On the other hand, one study on people in India reported reduced consumption of junk food²⁵.

A balanced diet includes fruits and vegetables. In some cases, the consumption of these foods increased during the pandemic²⁶⁻³⁰. In other cases, people increased their consumption of fruits and vegetables during the pandemic, but also consumed more processed meats and sweetened beverages³¹. Some studies even found people eating less fruits and vegetables during the pandemic³².

However, the impact of the pandemic on nutritious eating varies. In Ghana, for example, people drank less alcohol and ate less junk food and more fruits and vegetables³³.

Health and well-being impacts: ups and downs

In many countries, staying at home during the pandemic correlated with gaining weight. As one study put it: “Individuals gained more weight the longer they stayed at home during lockdowns”³⁴. Even in a study where people claimed to eat at home nearly three-quarters of the time and eating healthy meals nearly half of the time, more than 25% of them gained weight during the pandemic³⁵.

Still, some studies found improvements in health during the pandemic. For example, a UK-based study found reduced glycemia in people with type 1 diabetes³⁶.

Conversely, some research suggested that the pandemic exacerbated some health problems, such as cardiovascular (CV) disease. As one author noted: “The COVID-19 pandemic has had a deleterious impact on the CV risk factors, with an increase in both sedentary and unhealthy food habits”³⁷.

The general trend towards poorer eating habits also contributed to an increase in some mental-health issues. One study concluded: “During the COVID pandemic, changes in nutrition

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When people did opt to cook more at home during the pandemic, their overall nutrition did not necessarily improve.

quality and habits were associated with greater anxiety”³⁸.

Despite increased at-home eating around the world during the COVID-19 pandemic, the outcomes indicated that home cooking is not always healthy cooking. Moreover, many factors — economics, food availability and others — created a complex pandemic-driven food ecosystem.

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How does **home cooking** affect well-being in different demographics?

PeopleImages/Stock/Getty

Key highlights

- Despite the potential health benefits of cooking at home across many sectors of society, more work is needed to encourage home cooking within some groups.
- Education is a key component to a life of healthy home cooking.
- Although some gender-based differences exist, this area requires more research.

Better education might improve nutrition

In general, people think of home cooking as healthier than other options. As one study put it: "Cooking at home is likely to be associated with benefits to diet and health"¹. These benefits, however, arise from eating home-cooked meals, not just eating at home. For example, one study stated: "Home cooking refers to the combination of actions required for preparing hot or cold foods at home, including combining, mixing and often heating ingredients"².

Making meals at home might be on the decline. As one study noted: "Households in the developed world have shifted away from home-cooked food towards ready-to-eat food"³. As this study added: "In the United Kingdom, home-cooked food represented more than half of the food budget in 1980, but less than a third in 2000".

Plus, improving well-being by cooking at home also depends on the ingredients. "Modern home cooking typically includes the use of processed food which can lead to negative outcomes, including weight gain," according to one study⁴. Another study, looking at of people quarantined during the height of the COVID-19 pandemic found that most of them cooked at home more, but they also consumed more homemade pastries and fried foods⁵. To

turn home cooking into more nutritious eating, one group of scientists has called for "more research on cooking education as a method for improving weight loss outcomes in the context of behavioural interventions"⁶. During healthcare visits, clinicians could even encourage making healthier meals at home, some suggest^{7, 8}.

Eating over the years: it pays to get a head start

Making nutritious home-cooked meals for a lifetime starts in childhood. One study stated that a "cost-effective preventive strategy for obesity is to increase individual home cooking skills from a young age, favouring healthy cooking methods, such as roasting, and boiling over fried foods, maximizing the anti-obesity properties of some ingredients rich in phytochemicals (e.g. soy and fibre)"⁹. Encouraging better eating among children typically depends on their parents¹⁰. As one study emphasized: "To promote healthy eating among children, the adults' cooking practices should be aligned with the preparation of meals made from scratch, taking into account the healthiness of what is being cooked"¹¹.

Studies of students at various levels of education find a correlation between the frequency of eating home cooking and the quality of their diets^{12, 13}. One study of

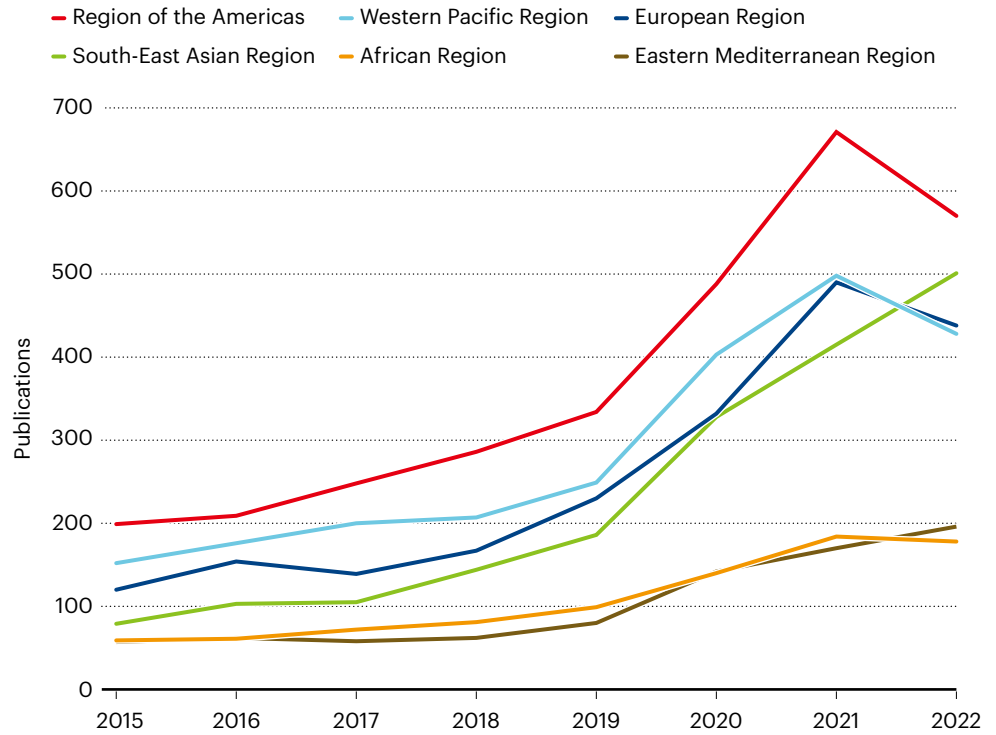


"Households in the developed world have shifted away from home-cooked food towards ready-to-eat food."

Figure 2.1

Yearly WHO region publication counts for cooking and well-being

While the Region of the Americas had the highest publication count in 2022, researchers in the Eastern Mediterranean Region have been publishing more papers, particularly since 2019, overtaking the Western Pacific Region and European Region in 2022.



students in Italy noted: “Eating away from home was associated with lower incidence of consuming vegetables, fruits, and legumes and higher incidence of consuming processed meat, salty snacks, and alcoholic drinks, compared with eating at home”¹⁴. As a result, eating away from home by students can contribute to obesity¹⁵.

Although some studies found poorer cooking skills in younger people¹⁶, one interventional study that educated students about food concluded that the results have the “potential to lead to longer term outcomes including changing eating behaviour and diet”¹⁷.

Many scientists explore how often adolescents eat healthy meals at home. For example, one study showed that adolescents eating away from home and consuming high levels of ultra-processed foods can make students obese, but still undernourished¹⁸.

A study of children and adolescents in the United States determined that

eating at home more often reduced the consumption of ultra-processed foods¹⁹.

Moreover, higher levels of home cooking can improve the health of adolescents beyond reducing obesity. As an example, one study of adolescents in Japan found correlations between less frequent home cooking and higher blood pressure²⁰.

Another study found that, even when living with family members, seniors often eat alone and noted that solitary eating “is a risk factor for mental health decline in old age”²¹. Eating with family members, however, can reduce depression in the elderly²².

The impact of gender on cooking

Gender often plays a role in who shops for food and cooks it. A recent US study found: “More than 80% of women aged 25 years or older indicated that they

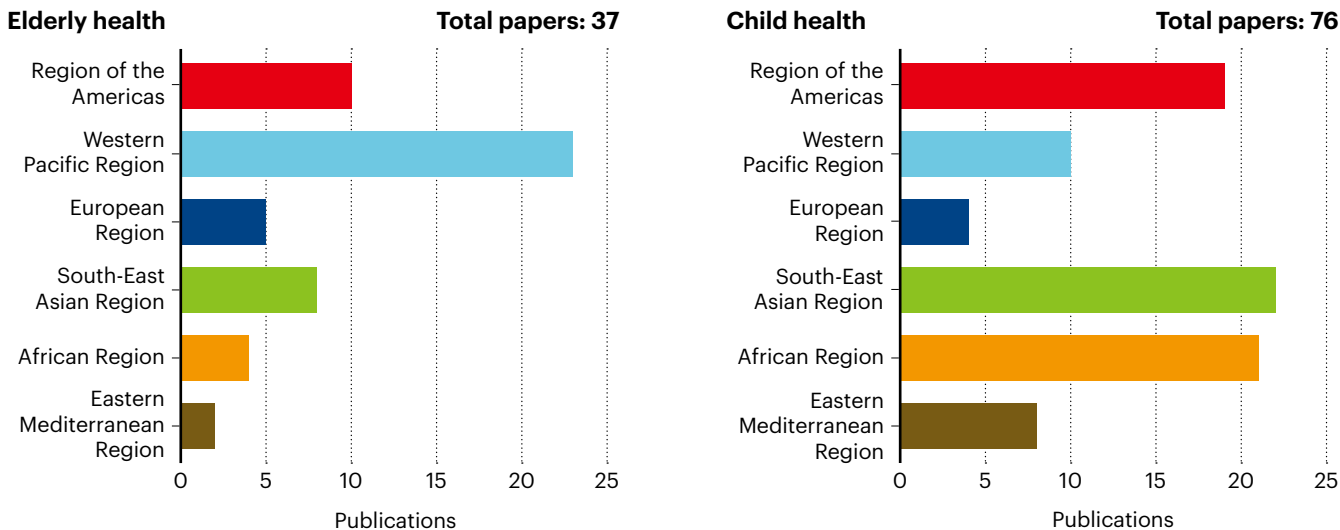
Demographics

Figure 2.2

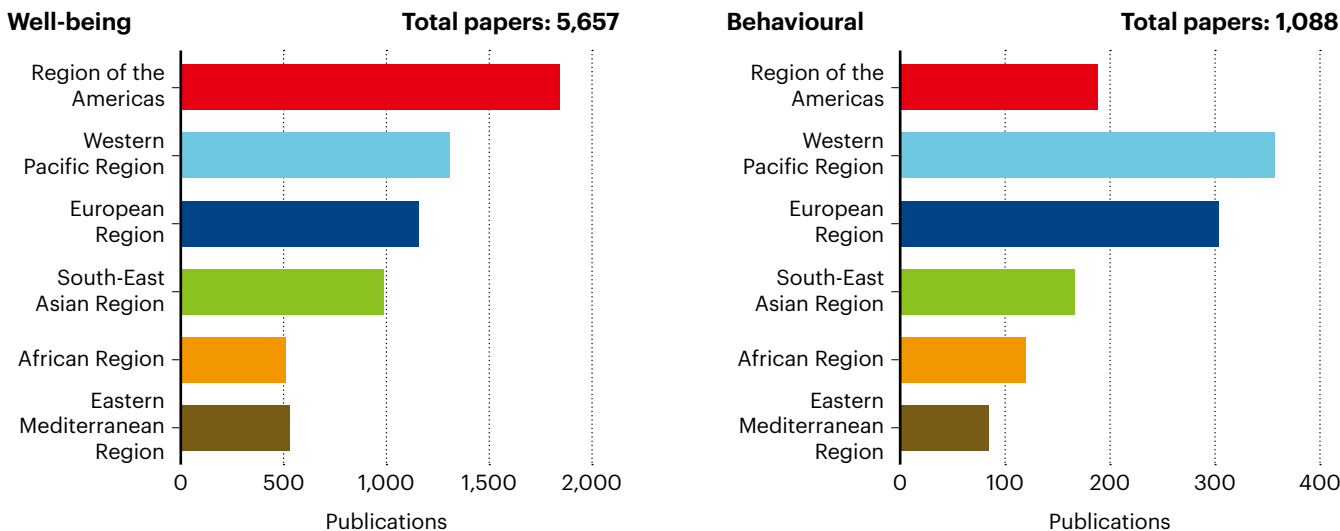
WHO regional differences in numbers of publications on cooking and other factors

Perhaps part due to the aging population in Japan, between 2015 and early-2023 the Western Pacific Region has been producing the most papers looking at cooking that also mention elderly health in the title or abstract, while the South East Asian and the African regions have been producing the most in terms of papers looking at cooking that also mention child health in the title or abstract.

**Some papers may be affiliated with more than one region.*



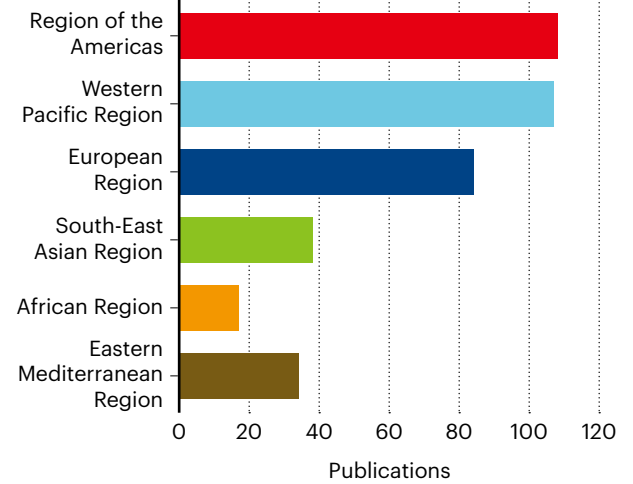
Between 2015 and early-2023, the Region of the Americas has been producing the most in terms of publications on cooking that mention words associated with well-being in the title and abstract, while the Western Pacific Region and the European Region are most interested in research on cooking and behavioural matters.



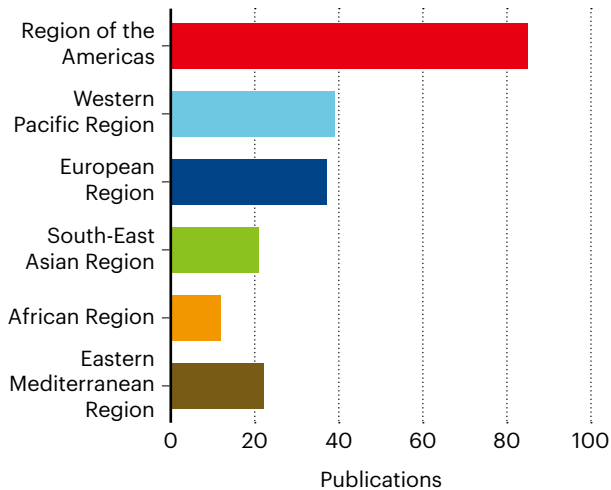
How does home cooking affect well-being in different demographics?

Between 2015 and mid-2023, the Region of the Americas, the Western Pacific Region and the European Region has produced a similar amount of papers looking at cooking and emotional health, while the Region of the Americas has produced the most by far in terms of publications focused on cooking and mental health. Cooking and physical health and noncommunicable diseases are less studied, but are dominated by the Region of the Americas. The Western Pacific Region has produced the most in terms of cooking policy and guidelines focused research, however from a very small pool of papers.

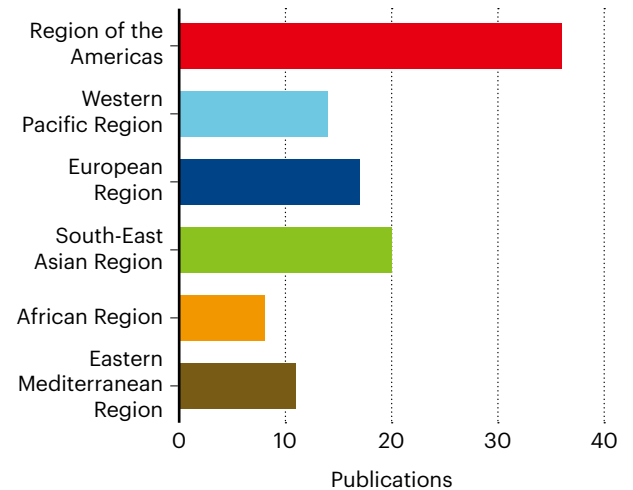
Emotional health Total papers: 320



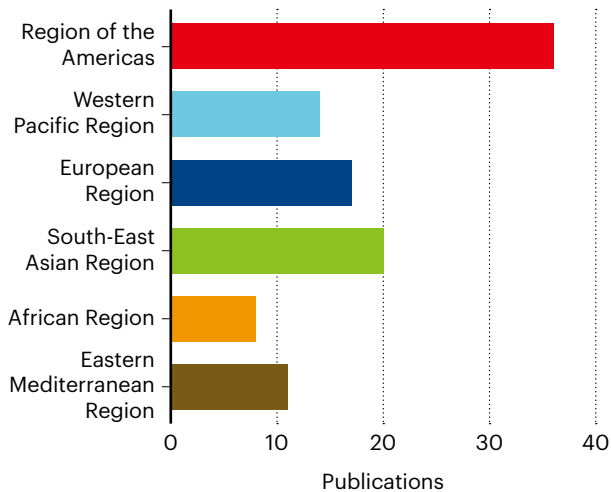
Mental health Total papers: 254



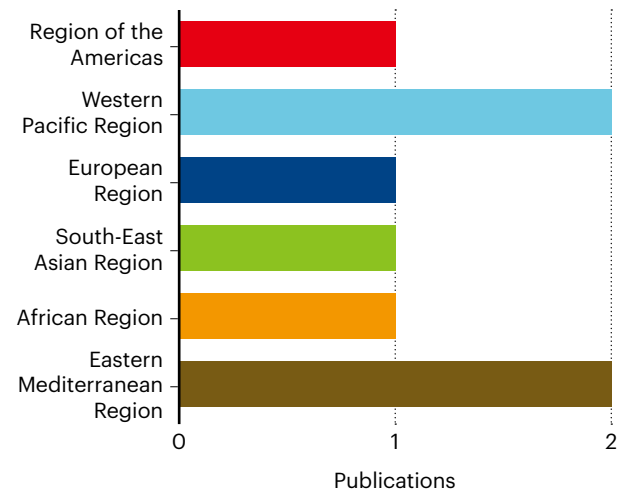
Physical health Total papers: 186



Noncommunicable diseases Total papers: 87



Policy and guidelines Total papers: 5



Demographics

were the person who did most of the planning/preparing of meals in their families²³. Another US study, however, showed increasing cooking among men, especially if they were college-educated, but still showed far more cooking by women. The author encouraged more research to determine any impact on the resulting diets²⁴.

Some studies do look for gender differences related to food in general. For instance, a study of adults 65–75 years of age in Denmark explored “satisfaction with food-related life” and found no gender-based differences²⁵.

Some gender-based studies, though, do find interesting aspects of well-being related to home cooking. For example, a study of women who work outside their homes in Malaysia showed they cooked at home less frequently, about half of them had a poor diet, and the scientists concluded that “simply devoting time to cooking food at home may not result in a healthy diet, since other variables such as socioeconomic position, attitudes, and family food preparation abilities may impact diet quality²⁶”.

Also, a study of new mothers in South Korea and China noted: “More pregnancy-related nutrition education should be provided and various and effective nutrition education programmes, which not only transfer information, but can be practiced in actual life, should be developed²⁷”.

Sometimes, gender-related studies reach surprising conclusions. For example, a study of the rate of eating out in South Korea found “positive associations of the daily eating-out rate with obesity and being overweight in South Korean women, but not men²⁸”.

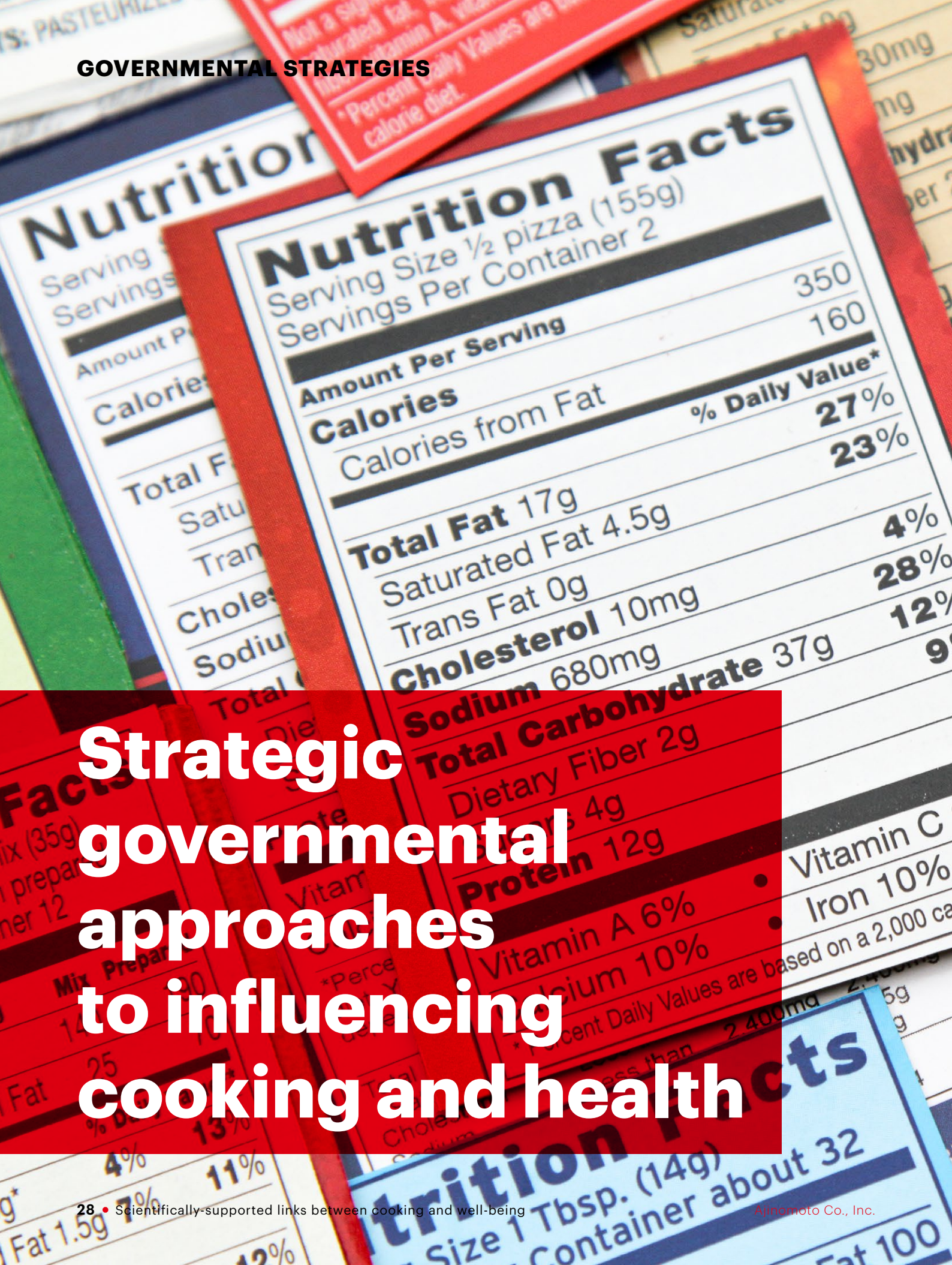
Overall, home cooking tends to improve the well-being of most demographic groups around the world. Nonetheless, some questions will only be answered through more research.

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Strategic governmental approaches to influencing cooking and health



Key highlights

- Many governments are exploring or mandating labeling that emphasizes the nutritional content of foods.
- Despite many approaches to reducing the intake of sodium, fundamental challenges remain.
- Two case studies — reducing salt consumption in Japan and obesity in Mexico — show limited success.

Know what's in your food

No matter what a person eats, from fast-food to a home-cooked meal, knowing the contents of the food and its nutritional value depends on access to information, which is rarely well advertised. So, governments around the world take a variety of approaches to making it easier for consumers to know what's in a food product or a meal, which can impact decision making.

As one review study of 60 interventions noted: “food labeling reduces consumer dietary intake of selected nutrients and influences industry practices to reduce product contents of sodium and artificial trans fat”¹.

Nonetheless, the different labeling approaches taken around the world can make comparisons difficult²⁻⁴.

One common approach is front-of-pack labeling (FOPL). With Australia's Health Star Rating system, for example, healthier foods get more stars, up to five⁵. With ultra-processed foods, however, the star rating is not always an accurate indicator of a product's nutritional content, due to inaccurate claims, technical weaknesses, design flaws and governance limitations⁶⁻⁸. Still, one study concluded that this rating system could provide “significant benefits to the community from the use of a single standardized signposting system for

healthiness across all fresh, packaged and restaurant foods”⁹.

Chile requires FOPL with black octagons to indicate high levels of calories, fat, sodium or sugar¹⁰. Although one study found that Chileans like the idea of this labeling, it is not always effective in changing what people buy¹¹. Peru also uses an octagon-based system to warn consumers if a product contains high levels of unhealthy ingredients¹².

Many countries use colour coding in FOPL. In France, the Nutri-Score (NS) FOPL uses a combination of colours and letters to indicate nutritional content^{13,14}. Mexico's Nutritional Traffic Light¹⁵ and the United Kingdom's Traffic Light system¹⁶ rely on three-colour labels to indicate a product's levels of fat, sugar, and other nutrients.

In some cases, labeling methods can even be considered for multiple countries. For example, one study noted: “The implementation of mandatory front-of-pack nutrition labeling is currently being discussed in the European Union (EU).”¹⁷ Using France's NS system as an example, this study added that modeling on real-life food samples showed that one could use the NS system's for harmonized mandatory front-of-pack nutrition labeling across Europe. One study that examined the potential of an of an NS-style system across several European countries concluded that the adoption and

Governmental strategies

implementation of uniform scientifically validated front-of-package labels, such as Nutri-Score, on pre-packaged foods and beverages “could help reduce the incidence of diet-related chronic diseases by means of improvement in diet quality”¹⁸. Nonetheless, the NS system does not work with all foods. As one French study pointed out: the NS system is not applicable to infants’ and young children’s formulas and to specific baby foods, the compositions of which are already laid down in European Union regulations¹⁹.

In the United States, the Nutrition Facts Label is based on the *Nutrition Labeling and Education Act of 1990*, which determines information required on food packaging, and one report stated: “There has been progress beyond the Nutrition Facts Label in recent years with front-of-package labeling and menu labeling, which is crucial given changes in consumption trends for food-away-from-home”²⁰.

Requiring labeling, even FOPL, is one thing, but analyzing the impact might

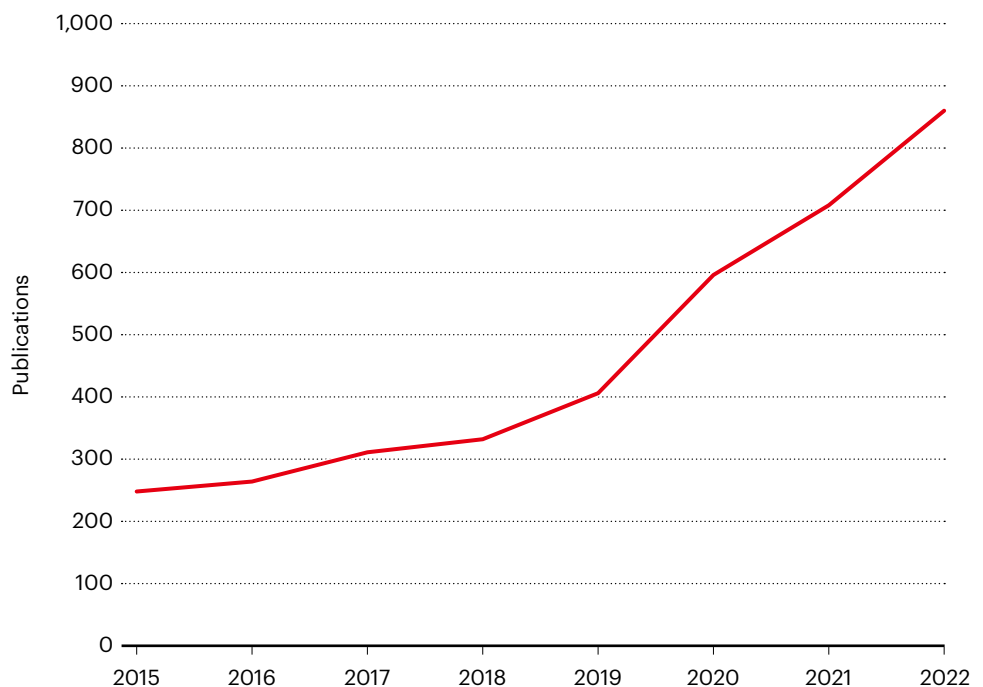
be best determined with advanced methods. One research team used various techniques, including brain-activity recordings, to study the impact of traffic-light approaches to labeling foods, and reached some unexpected conclusions: “A red code increased positive emotions toward sweet [ultra-processed food products] despite its explicit association with increased health-risks”²¹. Consequently, some methods of food labeling might create unintended results.

Beyond foods to be cooked at home, FOPL can also be applied to restaurants. One study that used the NS system in two restaurants in France found that customers consumed more nutritious meals and lower levels of calories, saturated fats, and sugars using the system²². It’s even possible that simply listing the calories of restaurant meals can lead customers to make reduced-caloric choices²³. Similarly, when a restaurant uses a real-time method that shows customers the accumulating calories when ordering, people order meals with fewer calories²⁴.

Figure 2.3

Nutrient profiling paper growth

There were 3,725 papers published on diet, nutrition and nutrient profiling between 2015 and 2022, and there has been a clear upwards trend in numbers of papers published annually, particularly since 2019.





apomares/E+/Getty

each year, is associated with excessive intake of sodium, a well-established cause of raised blood pressure and increased risk of cardiovascular disease²⁸. This report pointed out that the average person globally consumes 4,310 milligrams of sodium each day, which is more than twice WHO recommendation of consuming less than 2,000 milligrams per day.

Many countries also publish recommendations for sodium consumption. For example, the US's *Dietary Guidelines for Americans* suggests a daily limit of 2,300 milligrams, and even less for some groups, including people with hypertension²⁹. In the UK, the National Health Service (NHS) recommends a sodium limit of about 2,300 milligrams a day for adults, but less than 400 milligrams per day for infants under the age of one³⁰.

Beyond recommended levels of sodium consumption, government programmes have also attempted to address this health problem. As one example, the Victorian Salt Reduction Intervention in Australia was a four-year effort to reduce sodium consumption, and one study reported reductions in sodium in purchased food, but no change in the amount of salt used in cooking and at the table³¹. As this study noted: "The findings indicate that more intensive and sustained efforts aiming at the retail and food industry with national level support are likely to be required to achieve a measurable improvement in sodium intake at a state level."

Reducing sodium content in home cooking and through additions at the table faces some fundamental challenges. First, many people like the taste of food better with sodium added as salt during preparation. As one study of people in The Netherlands reported: "Health aspects did not play a major role in salt intake, whereas taste attitude was an important predictor of added cooking salt"³². Second, people typically have no idea

²⁵. One study even applied a traffic-light approach to the energy density and sodium content of foods in self-service restaurants, and more than half of the customers changed selections based on the available information²⁶. Even for food ordered online to be delivered, one team of scientists developed a measurement of the nutritional quality of available items, and the researchers claimed that the results showed "promise for the feasibility of an objective measure of healthiness that could be applied to all outlet listings on ... digital food outlet aggregation platforms," but noted that further research is required to assess the metric's validity, its desirability and value to users, and ultimately its potential influence on food choice behaviour²⁷.

Controlling sodium content: recommended limitations

As noted in some of the references cited above, sodium is often considered when considering the connection between food and health. According to a 2023 report from the World Health Organization (WHO): "The largest number of diet-related deaths, an estimated 1.89 million



“Google Trends revealed that the Japanese public’s awareness of salt reduction has increased.”

how much sodium that they consume each day. To address that issue, one research team suggested that an “intelligent household added salt monitoring system” should be designed and tested³³.

Economic factors, such as gross domestic product (GDP), also impact the consumption of sodium. As one multi-country study reported: “A significant inverse correlation between discretionary salt intake and a country’s per capita GDP was observed ($P < 0.0001$), such that for every \$10,000 increase in per capita GDP, the amount of salt obtained from discretionary sources was lower by 8.7%”³⁴.

To address the global issue of overconsumption, the WHO made several recommendations: lower the content of sodium in food products; emphasize a product’s sodium content with FOPL; and encourage behavioural changes involving sodium consumption through media campaigns²⁹. In addition, based on a meta-analysis, one group of experts reported: “Structural interventions such as mandatory reformulation of foods, food labeling, taxes or subsidies, and communication campaigns have shown to be the most effective in reducing the population’s sodium consumption”³⁵.

Two case studies: sodium in Japan and obesity in Mexico

Health Japan 21 recommends keeping daily salt intake to no more than 8 grams, which is about 3,100 milligrams of sodium³⁶. This dietary target exceeds some other recommendations by nearly 50% and lower levels could make significant reductions in heart disease in Japan³⁷. Nonetheless, reduced salt consumption might not be enough, because one study in Japan found: “Despite a significant decrease in daily salt intake, the decline in the combined prevalence of ... hypertension was non-significant”³⁸.

Still, other research suggests that lowering levels of sodium in processed foods could play a central role in reducing cardiovascular diseases in Japan³⁹. In addition, some research shows that food companies in Japan increasingly manufacture food products that are lower in sodium, but still taste good⁴⁰.

Moreover, some studies show an increasing awareness of the potential health benefits of sodium reduction in Japan. For example, one team of scientists took an online approach to analyzing public knowledge and concluded: “Google Trends revealed that the Japanese public’s awareness of salt reduction has increased.”⁴¹ These researchers added: “Related searches might provide insights when people search for salt reduction, which could be helpful for future effective interventions for understanding salt reduction.”

That knowledge in Japan could also be turning into action. From 2007–2019, people in Japan consumed less salt, although nearly three-quarters of the consumption continued to come from seasonings, such as soy sauce⁴².

For future investments in sodium reduction in Japan, two primary approaches could be continued: media campaigns about the benefits of consuming foods with less salt and encouraging the food industry to reduce the levels of sodium in processed foods. For cardiovascular disease, one study found more than five times higher economic benefits from the latter approach — sodium reductions on processed foods — but the estimates depended on the amount of money invested in the approach⁴³.

In Mexico, like many countries around the world, obesity is a public-health problem, and the country’s obesity rate increase by 42.2% from 2000 to 2018⁴⁴. In 2010, Mexico’s Ministries of Health and Education implemented policies to improve foods available in schools and to

increase the nutritional knowledge of students⁴⁵. In 2014, Mexico imposed sin-food taxes on drinks with added sugar and foods dense in calories to address the obesity problem, but people purchased the same number of calories⁴⁶. Even FOPL did not impact the amount of processed foods consumed in Mexico⁴⁷. Going even further, the Mexican government enacted a law in 2019 that required warning labels on foods that surpassed set amounts of calories, added sugars, and so on, and one model forecasts that this law will reduce obesity by nearly 15%⁴⁸.

To effectively reduce obesity in Mexico, experts recommend several approaches. For example, one research team concluded: “Mexico should implement or strengthen current policies to reduce purchases of ultra-processed food and sugar-sweetened beverages and to regulate the location and density of [convenience] stores⁴⁹. Another study noted that influences from the food industry, particularly in terms of ultra-processed foods, hampers obesity-reducing programmes because “Ministries of Health have simultaneously neglected to work closely with civil society, while legislative representatives have continued to benefit from industry campaign

contributions”⁵⁰.

In sum, the articles cited here reveal the complex relationships between what people consume — cooked at home, in restaurants, or ordered online — and improvements in health. Both FOPL and government programmes produce some success, but more research is required to determine the best ways to apply these programs and how to analyze the outcomes.

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Governmental strategies

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The impact of diet types on well-being

Key highlights

- Diet can have a profound impact on physical, mental and emotional health, yet the diet of most adults doesn't contain the recommended proportion of macro- and micro-nutrients.
- The Mediterranean diet has the most robust evidence of health benefits. These appear to derive from the antioxidant effect of high levels of fruit and vegetable consumption and low levels of red meat consumption.
- Highly restrictive diets are likely to result in nutrient deficiencies and more research is needed to establish their benefits.



The diet link

Poor diet is a leading cause of death by non-communicable diseases, posing a greater risk than other modifiable life factors such as smoking and drinking alcohol and drug use¹. While the impact of a poor diet is well accepted, what qualifies as an optimal diet is subject to debate. Part of the reason for the lack of consensus is that the majority of the research on human nutrition relies on observational studies, which, in turn depend on the accuracy of self-reported food intake.

A macronutrient and micronutrient view

All health-promoting diets seek to strike a balance between the three main sources of calories: carbohydrates, proteins and fats. The recommended total energy intake according to the World Health Organization from carbohydrates is 40–70%,² 10–35%³ for proteins and under 30% for fats⁴.

There are three main types of carbohydrates: sugars, starches and fibre. Rather than a specific percentage of carbohydrates, a healthy diet should optimize intake of high-quality carbohydrates. For example, sugar from fruit is preferable to added sugars in sweetened beverages, as fruits are also a significant source of vitamins and fibre. Starches from whole

grains⁵ are likewise preferred over refined sources.

Animal sources of protein such as meat, fish and eggs have a more diverse amino acid profile and are considered more digestible and bioavailable than plant proteins. In addition, oily fish are a good source of omega-3 fatty acids, which are known to be beneficial for cardiovascular health⁶. At the same time, high consumption of red meat has been linked to cardiovascular disease⁷, and processed meats have been linked to colorectal cancer⁸.

Unsaturated fats have been linked to a host of health benefits including improved insulin response⁹ and lower mortality¹⁰. At the other extreme, trans fats, which are made by hydrogenating vegetable oils with catalysts, have the opposite effect^{11,12} and have been banned in 40 (mostly high-income) countries. The evidence concerning saturated fat is mixed, with several studies linking it to heart disease^{13,14} and others claiming no link^{15,16}.

Although they are required in much smaller amounts compared to macronutrients, micronutrients nonetheless play an outsized role in health and well-being. Vitamin A deficiency, for example, is a leading cause of preventable blindness, impacting between 250,000 and 500,000 children every year¹⁷. But more is not necessarily better, as chronic, high consumption of vitamin A can lead to liver failure¹⁸.

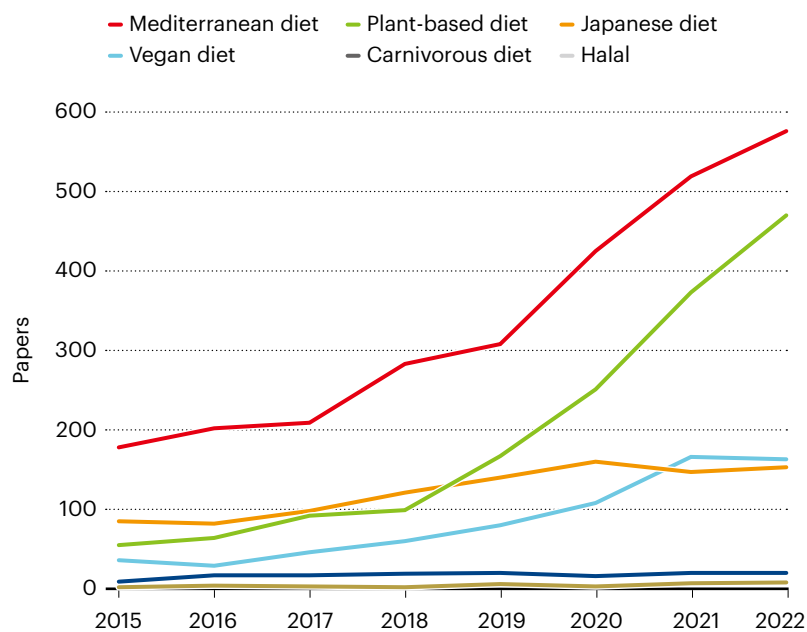
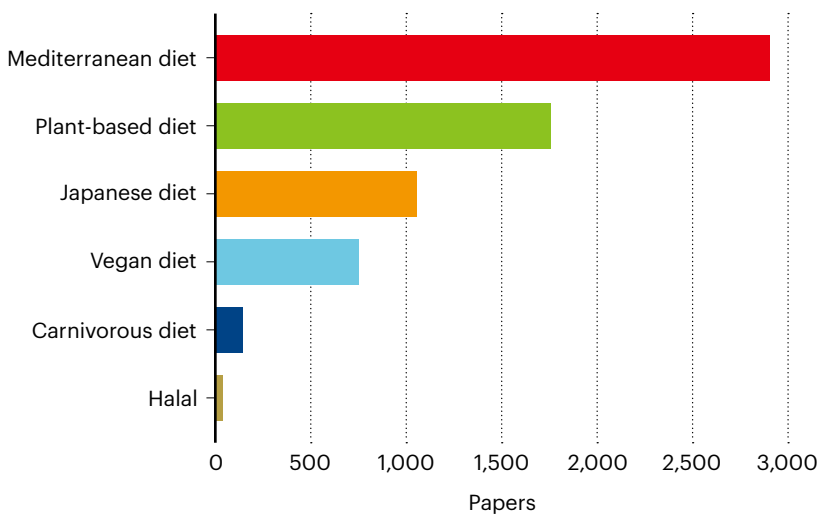
Brett Stever / Image Source/Getty

Diets

Figure 3.1

Which diets are attracting academic attention?

An analysis of 6,652 papers on specific diets published between 2015–2022 shows that the Mediterranean diet is by far the most studied, followed by a plant-based diet, Japanese diet, vegan diet, carnivorous diet and a Halal diet (see below). While the number of annual studies on the Mediterranean diet has more than tripled between 2022 and 2015, papers on plant-based diets and vegan diets have grown by more than a factor of eight and four, respectively, from a lower base. However, studies on both Japanese diets and vegan diets appear to have plateaued during the pandemic, suggesting that interest in plant-based diets is most persistent.



A whole of diet view

Despite a growing body of knowledge about what constitutes a healthy diet¹⁹, people in many countries eat too little healthy food and over-consume unhealthy food². Diet trends come and go, amplified more recently through social media. While many trendy diets claim to be supported by scientific research, the strength of the evidence can vary widely.

Of all the diets discussed in this review, the Mediterranean diet is the best-studied and most robustly supported (see left). Evidence for its positive impact on outcomes such as cardiovascular disease, cancer and mortality include not only observational studies, but randomized control trials on large sample sizes²⁰⁻²³.

Multiple mechanisms²⁴ have been proposed, including the lowering of blood lipids²⁵, the antioxidative effects of a diet rich in fruits and vegetables²⁶ and the production of metabolites from gut microbiota²⁷.

Given the relative success of the Mediterranean diet, researchers have also begun quantifying the effects of other traditional diets such as the Nordic diet, Japanese diet and cultural dietary practices such as the halal diet. Although promising, the evidence is mixed. For example, the traditional Japanese diet features vegetables, oily fish and fermented foods, but also tends to have high levels of salt, which can contribute to cardiovascular problems²⁸.

Low carbohydrate diets are not new, although previous iterations, such as the Atkins diet, have fallen out of favour compared to the ketogenic (keto) diet. The keto diet severely limits carbohydrate intake, replacing it with fat. This approach can lead to weight loss²⁹ and the reversal of metabolic syndrome³⁰, particularly in patients with type 2 diabetes. There is



●●●
A balanced diet should prioritize high-quality carbohydrates... lean animal proteins and beneficial unsaturated fats.

also emerging evidence that the keto diet could benefit those suffering from cancer, polycystic ovary syndrome³¹ and neurological diseases³².

In the long-term, however, there are some limitations to the keto diet.³³ Firstly, weight loss tends to plateau or reverse after six months, possibly due to the difficulty of adhering to a highly restrictive diet. The avoidance of carbohydrates could lead to poor fibre intake, while the high proportion of fat can elevate blood low-density lipoproteins (LDL) and raise the risk of cardiovascular disease³⁴.

Conversely, avoiding meat and animal products can be part of a well-balanced diet and is widely practiced for religious, ethical and health reasons. Vegetarian and vegan diets are linked to benefits such as lower mortality from ischemic heart disease³⁵ and reduced risk of certain cancers³⁶.

However, vegetarians and vegans need to ensure they consume adequate amounts of protein and micronutrients, which are more difficult to obtain from plant-based foods. For example, low levels of vitamin B12 and calcium might be why vegans are more likely to experience bone fractures³⁷. Furthermore, the quality of the diet matters³⁸, with unhealthy

plant-based diets largely comprised of refined grains and sweetened beverages leading to higher risk of death, cardiovascular disease and cancer^{39,40}.

Instead of restricting carbohydrates, the 'carnivore' diet completely removes them and focuses exclusively on proteins. Self-reported health benefits include a reduction in body mass index and medication use in patients with diabetes. However, the same study also found that the diet caused elevated LDL, which is linked to cholesterol and heart disease⁴¹.

The impact of poor dietary choices on non-communicable diseases is undeniable. While defining the ideal diet remains contentious due to reliance on observational studies and self-reported data, certain principles hold true. A balanced diet should prioritize high-quality carbohydrates from fruits and whole grains, lean animal proteins and beneficial unsaturated fats, while limiting trans fats. The Mediterranean diet emerges as a well-supported option, with evidence of positive effects on health. However, diverse diets like the keto, plant-based and carnivore diets show potential benefits alongside caveats, underscoring the complexity of dietary choices and their far-reaching implications.

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The influence of **taste** on diet

Key highlights

- Taste has a significant effect on hormonal responses that impact well-being, which, in turn impacts mood, nutrient intake, satiety, and food consumption.
- Taste has been shown to influence nutrient intake, body mass index (BMI) and heart disease.
- Separate tastes yield ambiguous information about nutritional composition, particularly in more complex foods.



The interplay of taste, mood and mind

Taste affects well-being from biological, psychological and psycho-social perspectives. A small 2021 study, for instance, focused on the effects of taste loss in COVID-19 patients and found that 76% of patients indicated that their overall quality of life — ranging from physical health, work-life and financial security, to partnerships, friendships, leisure, and emotional stability — deteriorated after losing their sense of taste.

The negative effects included feeling “less aware of own hygiene” (38%) and “less interest in food and drink” (23%). Loss of smell also led to decreased appetite (66.5%), impacting nutritional health and a depressed mood was a common symptom affecting well-being (15.8%)¹.

Recent advances in neuroscience shed light on the complex relationship between taste, mood, and cognitive processes. For example, a small-scale functional magnetic resonance imaging (fMRI) study, conducted in May 2023, unveiled intriguing insights; patients with taste loss experience changes of functional connectivity between brain regions not only relevant to taste processing, but also to cognitive function².

From another physiological perspective, taste triggers cephalic phase responses, involving gastric secretions, before food enters the stomach, resulting from the sight, smell, thought, or taste of food. These responses prepare the body for food digestion and absorption and include hormonal responses, such as increases in circulating insulin (hormones are the most studied mechanism linking cooking and well-being, see graph on page 44). This impacts mood, nutrient intake, satiety, and food consumption, which has implications for the risks of developing obesity and diabetes^{3,4}.

kapakki/E+/Getty

Taste

Hormones produced in the tongue may also influence the amounts and types of food eaten⁵. Taste receptors in the gastrointestinal tract also release gut hormones that can affect food intake by inducing satiety^{6,7}. So the manipulation of taste perception may have a role in the management of obesity⁸.

Signals about the presence of food in the mouth and gut are transferred to the brain via several signal systems involving neurotransmitters, including glutamate, serotonin, GABA, ATP and noradrenaline⁹. Within the central nervous system, glutamate is the major excitatory neurotransmitter¹⁰, and plays a critical signaling role by activating umami taste receptors.

The vagus nerve, a key part of the gut-brain axis, also plays a small role in the sensation of taste near the root of the tongue. Major depressive disorder, for example, has been associated with disturbances in functions affected by the vagus nerve¹¹, and vagus nerve stimulation, an approved therapy for treatment-resistant depression and epilepsy, is associated with self-reported sweet cravings in depressed patients¹².

Dopamine: bridging taste and mood

Dopamine, a pivotal neurotransmitter, has emerged as a bridge between taste and mood within the brain's reward system. Pleasurable tastes orchestrate the release of dopamine, heightening mood and reinforcing positive associations with flavours. However, imbalances in neurotransmitters, such as dopamine and serotonin associated with depression, along with stress-induced cortisol release, can affect perceptions of how food tastes. Depression linked inflammation, medication side effects, and gut health changes also impact taste perception, and change eating patterns¹³.

Depression can also lead to anhedonia, a lowered ability to feel pleasure, altering eating and taste perceptions. Shifts such as emotional eating or avoidance due to depression can further influence taste preferences. Conversely, alterations in taste, caused by factors such as stress or medications, can impact mood. While taste isn't thought to be a direct cause of depression, the connection between the two underscores the multi-directional interplay

Figure 3.2

Which mechanisms linking cooking and well-being are being studied?

Hormones appear to be by far the most common primary mechanism studied in our dataset, although the second most studied mechanism, taste, has been climbing in terms of publication numbers since 2018.

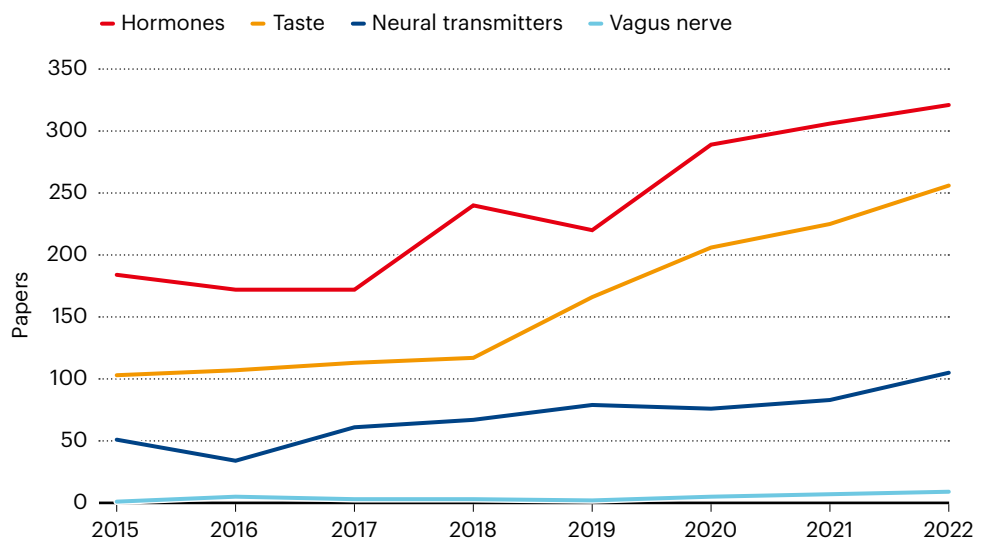
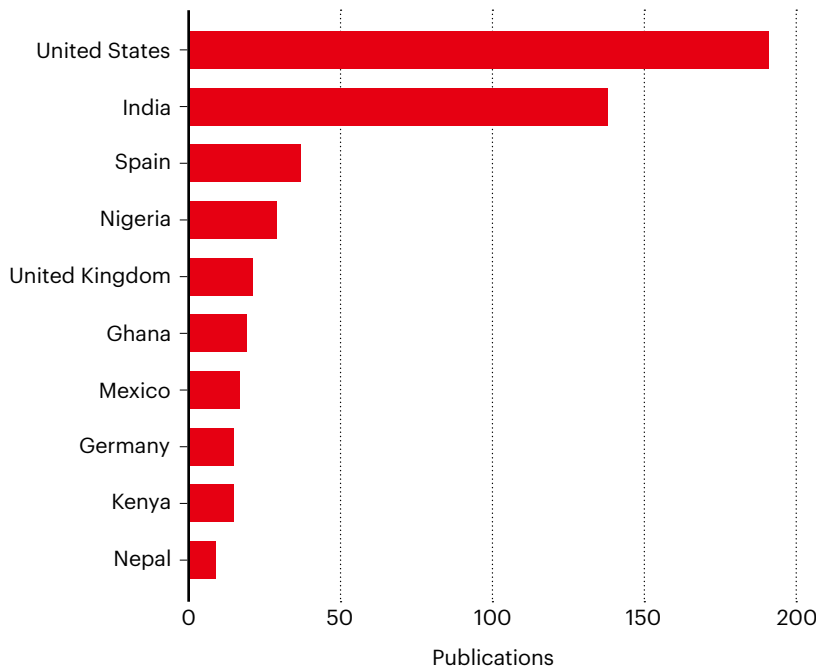
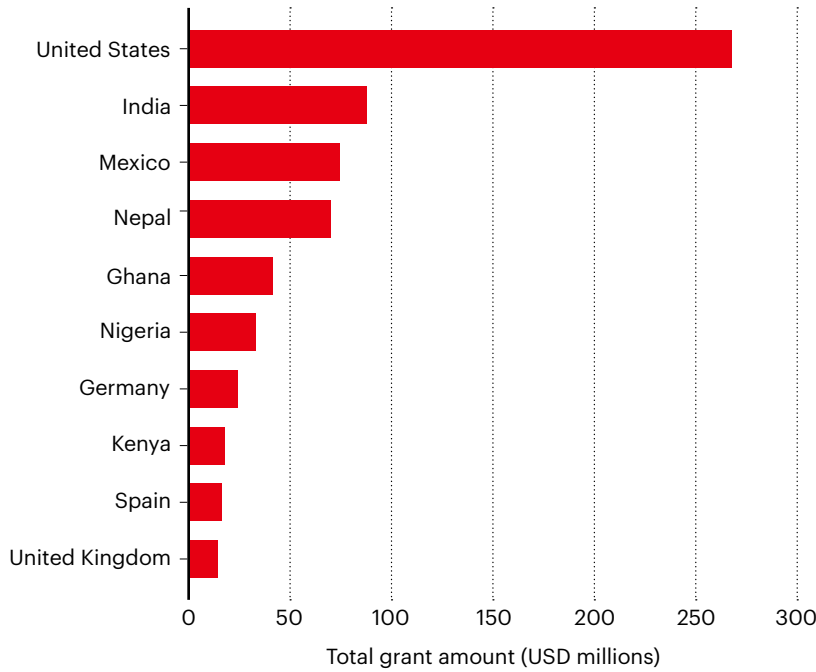


Figure 3.3

Which countries are studying umami?

Between 2015 and early-2023, the United States, India, Nigeria, Spain and the United Kingdom were the leading nations in terms of numbers of publications on cooking, well-being and umami. However, Mexico, Nepal and Ghana are notable as they appear to be putting large amounts of funding into research on this topic.



UMAMI: The most recently recognized taste

Although scientists have known about the umami taste for decades, it is only recently that it has gained wider public recognition as the fifth primary taste³⁰. Umami is elicited by L-glutamate, typically via sodium salt, monosodium glutamate (MSG) and some amino acids and purine nucleotides. The umami found in MSG can result in a more pleasant taste and a magnification of the perception of saltiness, and it thus can be used as a taste enhancer in everything from meat to bread³¹⁻³⁴. MSG may thus be useful in the reduction of dietary sodium intake, which is a leading cause of diet-related deaths due to its links to high blood pressure, heart diseases, strokes and poor bone health. Glutamate is found in a wide range of foods, but despite that, this taste is not generally included in taste evaluation tests in European countries because it has been found to be hard to conceptualize by the population³⁵. Other studies have suggested that people from some ethnic backgrounds may be less able to taste MSG, which may go some way to explaining the popularity of umami research in some countries and not others³⁶.



Tevarak/Stock/Getty

Taste

between dopamine, mood regulation, taste perception, and dietary habits¹.

Taste and disease

Taste sensitivities are also known to influence diet. For example a decreased sensitivity to the taste of fats is associated with an increased consumption of fat¹⁴.

In one group of American adults there is a significant correlation between the ability to identify fattier foods and preference for such foods, for example¹⁵. Low fat taste sensitivity has also been associated with higher BMI, and associated diseases¹⁶.

Individual sensitivity to taste sensations is also related to preferences for fruits and vegetables.¹⁷ And early exposure and familiarization to foods has a strong influence on individual perceptions of taste, and thus has an impact on one's physical health¹⁸. Repeated exposure to fruit and vegetables in hands-on community cooking sessions has been shown to increase children's acceptance of these foods, for instance¹⁹.

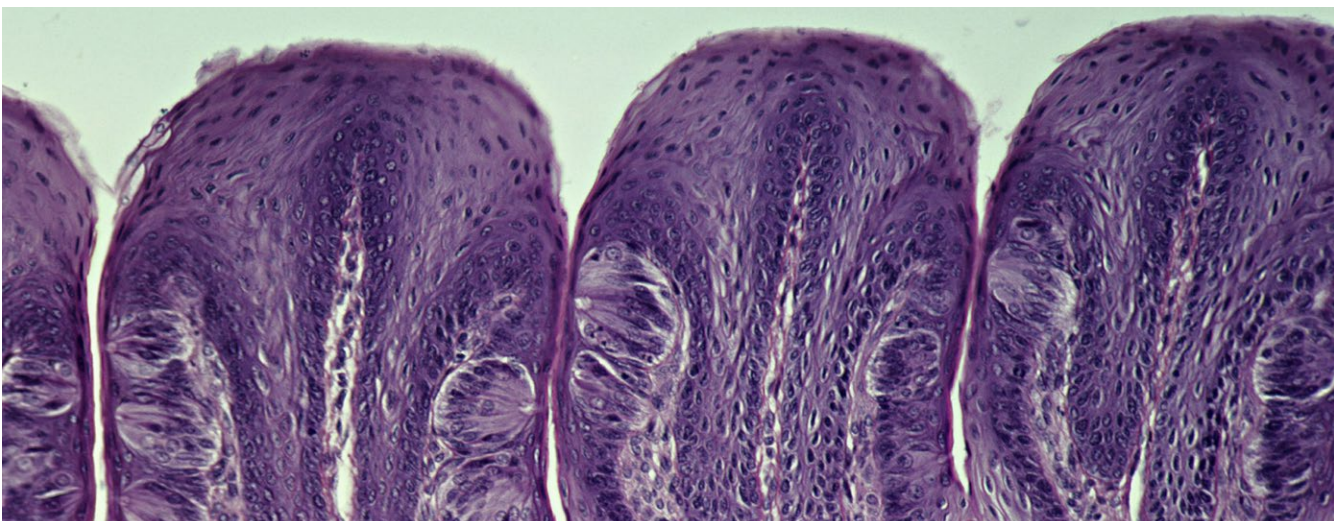
Higher intakes of sodium from processed and ultra-processed foods were associated with a preference for higher concentrations of salty taste in

adolescents²⁰. Dietary intake of sodium was also associated with preferences for higher salt concentrations in a randomized control trial in Brazil²¹. In addition, a high salt-taste recognition threshold has recently been linked to an increased risk of coronary heart disease²². Recent research has suggested this may be addressed by harnessing umami flavours, in some populations (see page 45).

Can we use taste to detect nutrients?

The relationship between taste and an ability to perceive nutrient content is not one to one. Links have, for example, been observed between sweet taste intensity and mono-disaccharide content, salty taste and sodium content, sour taste and organic acid content and protein content and umami taste intensity. While fat sensation, rather than taste alone, has been linked to lipid content²³.

But separate tastes, such as sweetness or bitterness alone yield ambiguous information about nutritional composition. Sweet tastes, for example, are thought to help identify foods with a high caloric or micronutrient density. However, in one study, the sweetest foods, such as fruits,



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●●●
Taste-nutrient relationships have been shown to be broadly maintained across different degrees of food processing.

were shown to have a relatively modest caloric density and low micronutrient density, whereas the blandest foods, such as grains and meat, had a relatively high caloric and high micronutrient density²⁴. What's more, the nutrient-signalling function of taste is less efficient in more complex food due to competing tastes²⁵. This may be why the taste system is merged with inputs from the other senses, such as smell, and the intestinal nutrient-sensing systems.

Nonetheless, taste-nutrient relationships have been shown to be broadly maintained across different degrees of food processing, suggesting there is some correlation between taste and nutrient content.

In terms of cooking, although cooking increases the flavour and digestibility of food, it can also increase toxic components such as Maillard reaction products, furan, heterocyclic aromatic amines, acrylamide, acrolein, and trans fatty acids^{26,27}.

Modern technologies using lower temperature and faster cooking times can reduce the generation of these hazardous compounds²⁸. A low-heat, slow cooking method for beef generates primarily lipid degradation products, while high-heat, fast cooking, the most highly rated by consumers, generates more Maillard reaction products²⁹.

Metrics used to evaluate the links between cooking and well-being

In evaluating the links between cooking and well-being, several key metrics are employed.

Observational/Questionnaires

Surveys and questionnaires are used to gather data on dietary habits, cooking

practices, food preferences and overall well-being. These self-reported responses help researchers understand the perceptions of individuals and behaviors related to cooking and nutrition.

- **Dietary surveys**

Questionnaires and interviews to assess dietary habits, cooking frequency and food choices.

- **Food frequency questionnaires (FFQs)**

Detailed FFQs help capture the frequency and quantity of specific food consumption, aiding in the assessment of dietary patterns related to cooking habits.

- **Quality of life (QoL) surveys**

Researchers use QoL surveys to gauge the broader impact of cooking practices on the well-being of individuals. These surveys encompass physical, mental and social dimensions of life.

Biometric indicators

The emphasis in research and development (R&D) is on biometric measurements, which provide objective data. These indicators include:

- **Anthropometric measurements**

This involves assessing physical characteristics such as height, weight, body mass index (BMI), waist circumference and body composition. These measurements help in understanding the impact of cooking on physical health, including weight management.

- **Blood biomarkers**

Analysis of blood samples is conducted to measure various biomarkers, including cholesterol levels, blood glucose, inflammation markers (e.g. C-reactive protein), and nutrient concentrations. These indicators offer insights into nutritional status and overall health.

- **Blood pressure**

Monitoring blood pressure, specifically systolic and diastolic readings, is crucial for evaluating cardiovascular health and any cooking-related effects on it.

• Metabolic markers

Assessment of metabolic indicators like insulin sensitivity and glycemic control helps determine how cooking practices influence metabolic health.

• Inflammatory markers

Measurement of markers associated with inflammation aids in understanding the impact of cooking on inflammation levels within the body.

Cognitive function tests

Some R&D endeavours include cognitive function assessments, such as functional magnetic resonance imaging, to explore links between cooking, dietary choices and cognitive health. These tests evaluate memory, attention and overall brain function.

Cooking skill assessments

In R&D focused on cooking interventions, assessments of cooking skills and proficiency are conducted to evaluate the effectiveness of cooking-related interventions.

Taste perception tests

Some studies may involve taste perception tests to assess the sensitivity of an individual to tastes and preferences, potentially linking these factors to cooking practices.

Nutrient intake analysis

Measurement of nutrient consumption through dietary records or recalls to evaluate nutritional quality.

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RECOMMENDATIONS

Some areas for further research

Contextualized home-cooking effects

Why do some populations (such as women in midlife)^{1,2} reduce their consumption of nutrient-dense food when cooking at home, whereas most do not? Most of the research on dietary choices during the COVID-19 pandemic and demographics suggested that in order for home cooking to contribute to well-being, it is important to have nutritional literacy and to be able to prepare healthy meals affordably and easily³⁻⁶. Understanding the context and reasons behind variations in the health outcomes of home cooking is important.

Behavioural and psychological factors

Understanding the motivations, barriers and decision-making processes related to home cooking can provide insights into how to promote healthier eating habits.

Impact of the local environment

Discovering how the local food situation (including access to fresh and minimally processed foods) affects the relationship between home cooking and diet quality could help to identify structural barriers to healthy eating.

Psychological factors

Explore the more complex multi-directional relationship between psychological factors (such as stress and depression) and dietary choices.

Inflammation and dietary interventions

Continue to examine the relationship between inflammation and mental-health disorders and the potential of dietary interventions to reduce inflammation. Research should focus on the effects



of dietary patterns (such as the Mediterranean diet) on psychiatric symptoms.

Food insecurity and home cooking

Explore the relationship between food insecurity and the decision to prepare food at home during the pandemic. Investigate how food-insecure households coped with limited access to quality food and whether home cooking helped alleviate or exacerbate food insecurity. Analyze how disruptions in food-supply chains and food availability affected the dietary choices of individuals. Investigate whether limited access to certain foods influenced the types of meals prepared at home.

Impact of working from home

Analyze the influence of remote-work arrangements on cooking patterns and mealtime behaviours. Explore whether working from home led to more or less time spent on food preparation and its impact on overall nutrition.

Long-term health outcomes of pandemic-related dietary changes

Conduct longitudinal studies to examine the long-term health consequences of dietary changes during the pandemic. Analyze how shifts in eating habits (including increased consumption of processed foods and snacks) may contribute to the development of chronic health conditions and mental-health issues over time.

Gender disparities in cooking responsibilities

Examine the influence of gender-driven cooking patterns on the nutritional quality of meals prepared at home. Analyze whether households where mainly women cook have different dietary outcomes to those with more equitable distribution of cooking responsibilities.

Discovering who could most benefit from umami

Some research suggests that there may be a genetic element heightening perceptions of umami, which vary in different regions of the world⁷. Understanding the extent of this effect and its mechanisms will help to better assess how umami could be used to help reduce salt consumption globally.

Taste loss and quality of life

The impact of taste loss on the overall quality of life is a key area for further research. Investigate taste loss not only in COVID-19 patients, but also in individuals experiencing disordered taste due to other causes. Explore the long-term consequences of taste loss on various aspects of well-being, including physical health, mental health, social interactions and daily functioning.

Neuroscience of taste and mood

Explore potential interventions that target taste-related brain regions to improve mood and overall well-being.

● ● ●
Investigate taste loss not only in COVID-19 patients, but also in individuals experiencing disordered taste due to other causes.

Recommendations

Taste, nutrient perception and dietary habits

Investigate how individual differences in taste sensitivity influence food preferences and choices.

Sodium-reduction strategies

Studies could investigate the economic and societal impacts of sodium-reduction strategies to determine their long-term sustainability and feasibility.

Obesity prevention and policy evaluation

Research should examine the influence of the food industry on policy implementation and identify effective strategies to counter industry lobbying and campaign contributions.

Science-communication opportunities

As mentioned above, genetic factors may affect perceptions of umami flavours.¹ This would be of great interest to a wide readership. For example, do some countries have a natural advantage in being able to implement umami-related salt-reduction strategies?

A story about the roles home cooking and whole foods play on protein quality intake, and the links this may have to brain health and cognitive ability would be popular, and there is research to support it.

Polyphenols appeared as a highly cited link between cooking and inflammation, metabolic disorders, other noncommunicable diseases and neurodegenerative diseases⁸⁻¹⁰. If the links between home cooking and polyphenols can be established, a long investigative article digging into the benefits of cooking and polyphenol consumption would be of great interest to a generalist audience.

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To provide the most robust analysis possible, Nature Research Intelligence used multiple data sources for this report. Data sources included Digital Science's Dimensions data (research publications, a grants database and policy documents) combined with wider searches by our writers based on information gleaned from this data. The following steps were taken to extract relevant document sets covering a publication window from 1 January 2015 to 27 March 2023. This date range was chosen to show the most recent five-year trend before any publication output aberrations created by the COVID-19 pandemic, as well as the continuing to look at trends during the COVID-19 era.

**Document set:
Cooking and well-being – 23,998 documents**

The creation of the 'cooking and well-being' document set followed a multi-staged article extraction approach, returning; All articles between 1 January 2015 and 27 March 2023 with the below keywords related to 'cooking and eating' in the title and/or abstract.

Total: approx. 83,000 documents

Keywords

Cooking, cooked, eating out, dine-in, dine-out, street food, food take out, food take away, take out food, take away food, restaurants, cooking at home, cooked at home, home cooked, home cooking, eating at home, home eating, family dining, eating with family, cooking for family, solo eating, eating alone, alone eating, social eating, communal eating, commensality, group eating, processed food, frozen food, junk food, prepackaged food, ready-made meal, ready-made food, dehydrated food, fast food

From this dataset we extracted papers with words related to 'well-being' in the title and/or abstract.

Keywords

Well-being, wellness, prudential value, quality of life, joy, satisfaction, welfare, contentedness, healthiness, happiness,

resilience, connectedness, belonging, mental health, physical health, elderly health, longevity, emotional health, psychology, nudge, behavioural, umami or taste, medicine, obesity, child health, appetite, cognitive health, policy, guidelines, Covid, Corona, healthy eating, salt reduction, subjective indicators, biometric indicators, noncommunicable diseases

These were checked for off-target papers and adjusted to remove papers related to agricultural, livestock and biofuels research. The above stages returned **23,998 documents**.

**Document set:
Nutrient profiling – 4,070 unique papers**

Additionally, we later created a dataset of all articles between 1 January 2015 and 3 May 2023 using the keywords nutrient profiling, nutritional profiling, nutrition profiling, which included 4,070 unique papers.

**Document set:
Diet and taste – 58,864 documents**

The creation of the 'diet and taste' document set followed a multi-staged article extraction approach, returning; All articles between 1 January 2015 and 3 May 2023 with the below keywords related to 'diet and nutrition' in the title and/or abstract.

Total: approx. 113,000 documents

Keywords

Sustenance, nourish, nutrient, nutrition, nutriment, diet, meal, ailment, pabulum

From this dataset we extracted papers with words related to 'diet and taste' in the title and/or abstract.

Keywords

Carnivorous diet, Mediterranean diet, Japanese diet, vegan diet, plant-based diet, halal diet, carbohydrate, fat, cholesterol, protein, fiber, fibre, water, macronutrient, vitamin, mineral, amino acids, supplement, micronutrient, taste, vagus nerve, hormones, neural transmitters

After analysing the dataset we removed papers based on the below false-positive keywords in the paper title or journal title:

False-positive keywords

Beetle, mosquito, prey, bumble, zebra, moth, sea otter, microbial fermentation, animal feed, spider, bioarchaeology, mesocarnivore, cat, cats, dog, ruminant, mammal, herbivore, grazing animal, pasture, wean, hermetia, black spider fly, cattle, aqua, animal, livestock, poultry, marine, dairy

By eliminating false positive papers, **58,864** unique papers fell under the diet and taste category

Geographic analysis

All analysis was carried out based on country mention — mentions of country names within the titles and abstracts of research publications as an indicator of which locations the research is targeting.

Grant analysis/Grant geographical analysis

All papers where grant/funding data was available were included in the grant analysis.

The grant value (US\$) identified for each paper was then aggregated across each document set to provide thematic breakdowns.

Geographical assignment of grants data is based on the affiliation of the country from which the paper emanated. The amounts shown are an aggregate of the values (US\$) for each country.

As an example of the reach of this data, of the 83,000 documents in the cooking and eating dataset, 2,678 had grant information attached.

Literature review

Editorial worked to draw out the most robust papers linked to the themes mentioned in the report's scoping document using title and abstract key-word searches of relevant datasets, with an eye to covering a spread of regions, as defined by the World Health Organization, where possible.

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February 2024
