https://doi.org/10.1038/s43016-025-01129-8

The mismatch between biological needs and the modern food industry

Barry Popkin, Shu Wen Ng & Lindsey Smith Taillie

The food industry has created ultra-processed food-like products that disrupt nature's biological matrix and exploit our innate preferences for sugar, salt and fat — with the goal of encouraging overconsumption and maximizing profit. Increases in obesity, other nutrition-related non-communicable diseases and environmental harms have occurred as a result. Only major political commitments and the adoption of healthy food policies will curb ultra-processed food's negative impact on global planetary and human health.

The past century saw rapid shifts in how we eat, drink and move. Technological, demographic and socio-economic shifts were key drivers of these changes. The expansion of the modern food industry, with its vertical supply-chain models, food chemistry and powerful marketing via television, print, social media and radio, heavily promoted ready-to-eat or ready-to-heat foods. As modern food science and food processing emerged to create what we now call ultra-processed foods (UPFs), dietary changes have increased further.

We are beginning to see the development of a set of impactful healthy food policies aimed at reducing UPF consumption and a few promoting the intake of real and minimally processed foods for lower income populations[1]. Yet, the food industry continues to exploit our biological preferences for energy-dense, sweet, salty foods through the aggressive marketing, promotion and pricing of highly engineered UPFs. As transnational food companies have already saturated the markets of high-income countries with UPFs, they are now seeking market growth in low- and middle-income countries (LMICs), many of which have growing populations and a rising middle class[2]. These dietary changes also have implications for planetary health, as UPFs are linked to an array of environmental harms such as plastic pollution and water overuse and are also occurring simultaneously to the ongoing adverse impacts of climate change on the overall food system[3].

The mismatch between biological needs and modern food technology

These changes stand in contrast to the pace of human biological evolution over millennia, which has been exploited by the modern food industry to influence our food preferences and choices (Table 1). For instance, our preference for sweetness was originally beneficial as it drove humans to consume berries and fruit and vegetables to provide us with nutrients needed for our survival and development. This preference has now been hijacked by the overuse of added sugars and sweeteners in foods targeted to all age groups in increasing levels over the past century[4].

Table 1 | Examples of how modern technology has taken advantage of biological traits for profit

Biological traits	Modern technology taking advantage of biological traits
Sweet preferences	Cheap caloric sweeteners, food processing creates habituation to sweetness
Thirst, hunger, satiety mechanisms	Sugar-sweetened beverages are marketed and sold in all regions of the world
Fatty food preference	Edible oil revolution — high-yield oilseeds, cheap oils now used by the modern processed food/vendor, stall & restaurant sectors
Desire to eliminate exertion	Technology impacts physical activity in all phases of work, home life and leisure, reducing energy expenditure and enhancing sedentariness
Snacking behaviour	Modern food marketing, widespread access to unhealthy, nonessential, ready-to-eat snack foods
Consumption of food with minimally processed ingredients	UPFs: basic grains and proteins are deconstructed to the cellular-level and then combined with additives, added sugar, sodium and saturated fat to create hyper-palatable products.

The column on the left shows human biological traits that have evolved over 100,000 years and the column on the right shows how the modern food industry exploits each trait for profit.

Similarly, as discovered in recent decades, what we eat does not impact what we drink and vice versa. DiMeglio and Mattes[5] showed us that our diet was barely impacted when we drank beverages of any form, thanks to the human body's vital need to drink water or other water-based beverages every 3–5 days. Food, by contrast, was historically scarce during many seasons — and people experienced seasonal hunger but gorged when food was available in other seasons. The UPF industry has exploited this and sugar preferences by creating and heavily marketing sugar-sweetened beverages and snacks[4]. Before the twentieth century, there really were no consistent snacking behaviours documented, but in the past century, modern ready-to-eat and ready-to-heat snacks have emerged to the point that snacking has become a fourth and fifth meal, including in LMICs where snacking has begun to represent a major source of caloric intake.

Additionally, before industrialization, the seasonal or occasional ability to kill key protein and fat sources such as animals or fish, as well as seasonality of availability, led to a desire to consume caloric-rich fat when available. Sodium was needed for a variety of biological needs (from fluid balance to many neuromuscular and cellular functions. Coupling these biological needs with technologies to successfully

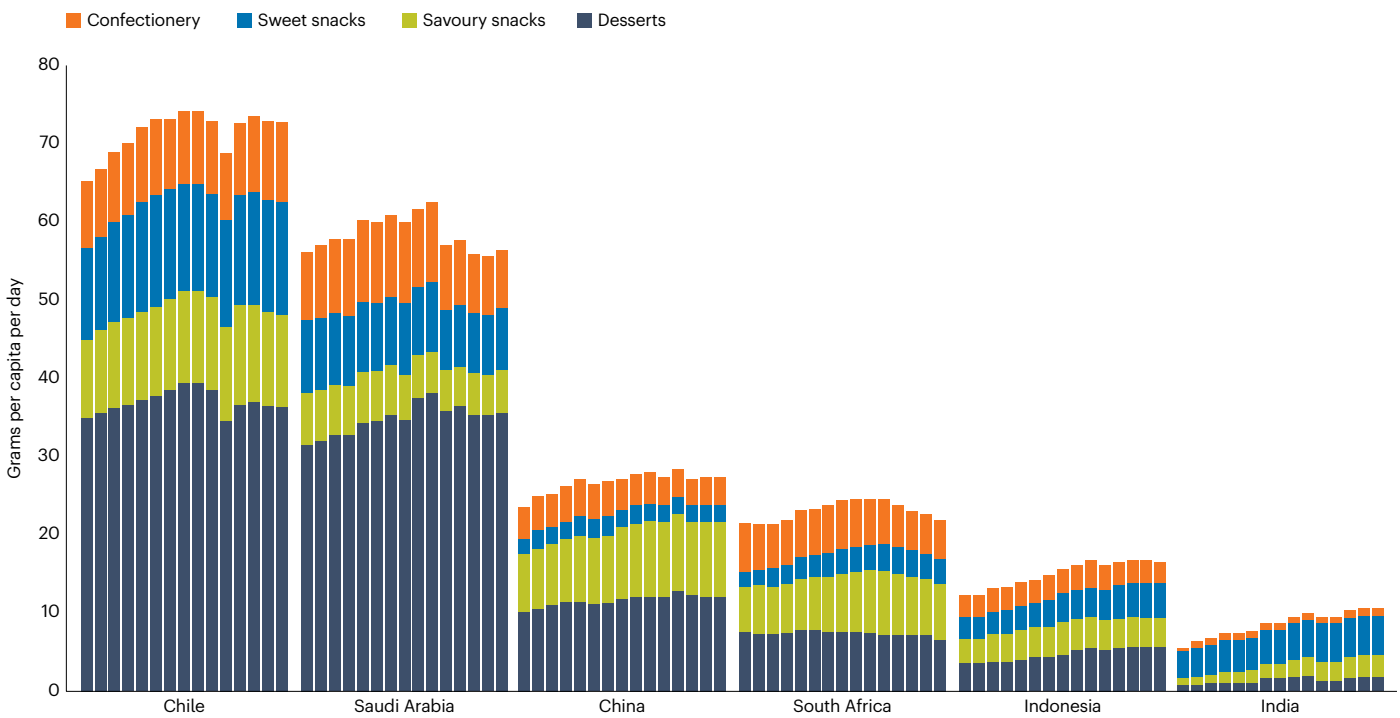


Fig. 1 | Trends in packaged snack and dessert sales, 2010–2024. Retail sales (in daily grams sold per capita for each country's total population) are aggregated from Euromonitor International's Passport database, which sources retail sales data from trade organizations and national statistics. These data approximate actual trends but probably underestimate total retail sales of foods high in sugar, salt, saturated or trans fats, and/or UPFs. The countries included were chosen because they had relatively robust data available in Euromonitor and give a sense of countries beyond very high-income countries from each region. Data from Euromonitor International.

and cheaply create edible oil allowed the world to replace olive oil and lard and other animal fats with modern vegetable oils, most recently dominated by one of the unhealthiest of these oils — palm oil. Similarly, added sodium is seen in an array of foods.

Last but not least was the creation of UPFs with properties previously unseen. These products are often high in saturated fat, added sugars or sodium (HFSS), and high in energy density and refined, quickly digested grains as well as additives such as preservatives, colourants, stabilizers, emulsifiers, flavourings, sensory enhancers and non-sugar sweeteners. The deconstruction of the basic food components of UPFs along with the use of an array of additives and flavourings have created a new class of foods. What differentiates these food-like UPFs from other less processed 'real' foods are three major shifts in food development. First is the molecular and/or cellular decomposition of grains, and often other food ingredients, which create foods that, when combined with other additives and ingredients, are new to humankind[6]. Second is the use of industrial additives, flavourings and colourants not found in normal kitchens. The molecular decomposition introduced by modern food science helps to create these cheap and ready-to-eat or ready-to-heat foods that are hyper-palatable and highly addictive[6,7]. Third, the bulk of these foods are high in added sodium, sugar or saturated fats[8] and are also high in energy density, which is subsequently linked to increased energy intake and weight gain. All of this is believed to be the reason that UPFs have been shown to not only be a key component of increasing risk for many nutrition-related non-communicable diseases (NCDs), including mortality, but also a risk to poor mental and cognitive health.

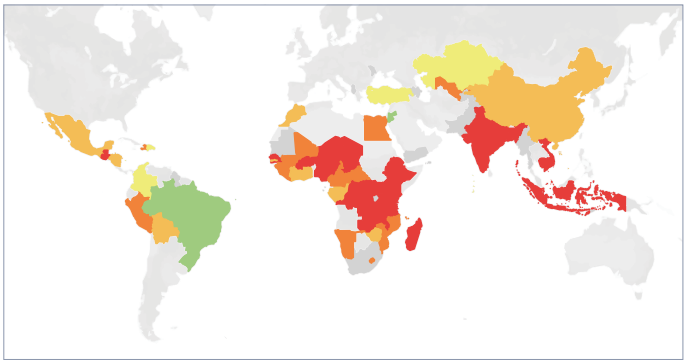
UPFs as a culprit

A large number of studies have documented the rapid increase in UPF consumption[9]. Although the United States and United Kingdom appear to have very high levels of consumption and other high-income countries consume a significant 30–50% of calories from UPFs, a more rapid increase of UPF consumption can be seen in LMICs, as shown in other publications about sugar-sweetened beverages (SSBs)[4,10]. Previous work has also shown the remarkable increase in the number of additives present in UPFs in the United States (even in a relatively short 12-year window) and in Chile[11]. Furthermore, research has shown for the USA that using Codex classes of additives plus flavourings identifies all UPFs[8]. Fig. 1 highlights the trends for selected categories of UPFs high in added sugar.

Data from the Demographic and Health Surveys (DHS) and the NCD-RisC factor use identical scales and height measurements to measure stunting and overweight and obesity. We find slower declines in stunting across lower-income countries than the rapid increases in overweight and obesity. Indeed, there have been declines in stunting in most LMICs, aside from areas facing wars and famine[12] (Fig. 2), while estimates show that both adults and children in lower-income countries are more likely to develop obesity today in most LMICs owing to higher incomes, modernized food marketing and cheaper UPFs, which are now highly accessible in all African countries, even in isolated villages and urban squatter areas.

By contrast, we highlight the shift in overweight and obesity. Based on recent trends, it seems safe to assume that soon in Africa and Asia, no country will show less than 30% overweight and obesity prevalence.

≈1990s–early 2000s
(Earliest survey years range from 1988–2013)



≈2010s–2020s
(Latest survey years range from 1999–2022)

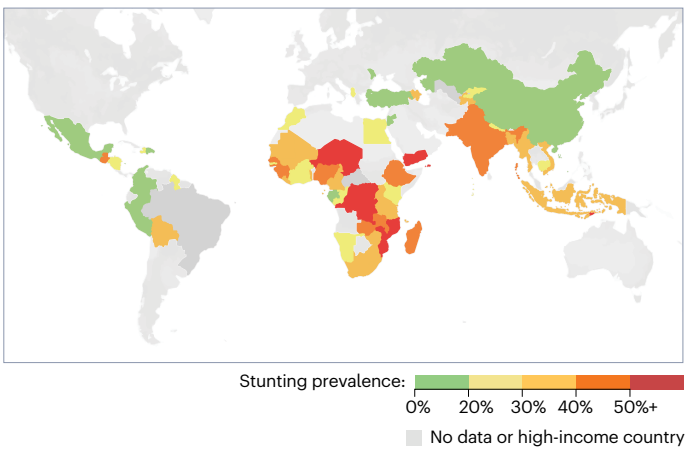


Fig. 2 | Stunting prevalence among children aged 0–4 years in LMICs in the 1990–2000s and 2010–2020s. The low decline in stunting prevalence among children in LMICs contributes to the high double burden of malnutrition among the poor. Data from the China Health and Nutrition Survey (China), the Indonesian Family Life Survey IFLS-1 and IFLS-5 (Indonesia), the National Survey of Health and Nutrition (ENSANUT) 2018 (Mexico), the 2019 National Survey of Health (Brazil), the Household Living Standards Survey 2002 (Vietnam) and the Demographic and Health Surveys Program (all other data).

At the same time, the high prevalence of overweight and obesity has slowly been shifting towards higher prevalence in low-income households than high-income ones. This has already occurred in all of South America, most of Central America and in many of the larger countries in Asia such as China and Indonesia. Together, LMICs are now facing high double burdens of malnutrition, with resultant increased risk of heart disease in both individuals with stunting and individuals with obesity.

Environmental sustainability is an additional key reason to reduce UPF production. Beyond the human health implications of UPFs, a growing body of literature has highlighted the water use of some key sugar-laden products, especially SSBs[9], as well as other environmental indicators impacted by the production and consumption of UPFs. This is only the tip of the iceberg, as many other UPFs are high in added sugar and others use excessive energy in their production and contribute significantly to greenhouse gas emissions as well as excessive water use, whereas real and/or minimally processed healthy foods such as produce and legumes use much less energy. Additionally, the packaging of UPFs adds to both health risks and environmental harm. For example, there is growing evidence around the link between higher UPF intakes and exposure to phthalates and bisphenol that have carcinogenic and endocrine-disrupting properties, which have been found in urine samples from nationally representative studies in several countries. Our planet's worsening health will only exacerbate human suffering owing to the increased frequency of extreme weather events that profoundly impact our food systems and further stress our mental health, physical health and healthcare systems. It will also continue to widen disparities and inequities within and across countries, resulting in more conflict. In other words, human and planetary health and wellbeing are inextricably connected.

Moving forwards

To address these pressing problems, both research and policy action are required. On the research side, it is critical to better understand the impact of UPFs on the human body so that we can better target the products that are the most health-harming. For example, the tightly controlled crossover trial by Kevin Hall et al.[13] showed that two weeks on a diet of UPFs led to 1 kg of weight gain, but it is currently unclear whether weight gain was driven by differences such as palatability or energy density or even the cellular, and in some cases molecular, decomposition of key components of UPFs. UPFs are characterized by ingredients such as added sweeteners, colourants and many other additives — each of which includes a large and diverse class of substances that could involve unique metabolic pathways that affect the body in separate ways. In addition, the impact that cellular decomposition of basic components of each UPF has on our health is unknown and unstudied. The latter is critical as this degradation of our food matrix and its health impact is only known by the food industry and access to the materials needed to study this effect — that is, the creation of foods unlike what mankind has ever eaten — is unstudied. Still more questions relate to the actual process of creating UPFs and how the subsequent degradation of the food matrix might affect digestion, metabolism and the gut microbiome (for example, consuming a peanut versus a reconstituted peanut-butter-like substance). Another important body of research relates to whether and how UPFs create a brain reward system that triggers addiction-like eating behaviours[7]. Multiple randomized controlled clinical trials are being conducted by researchers in an attempt to unravel the mechanisms by which UPFs increase our risks of early disability, mortality and morbidity.

The nutrition transition stage dominated by UPFs globally is well under way. Industry has learned how to effectively exploit our biology, which has evolved over many millennia. Failure to address this transition will lead to high health costs from the increased need for treatment of obesity, type 2 diabetes and other NCDs, as well as high environmental costs owing to the environmental damage caused by these products, including plastic pollution, water overuse and greenhouse gas emissions.

While scientists work to understand fully the mechanistic pathways of UPFs, given that the health and environmental impacts are already clear, public policy action is urgently needed to address the food environment factors that promote widespread consumption of UPFs, including price, availability and marketing. Many countries are already beginning to act, and although most to date have targeted a subset of UPFs (for example, sugary drinks and HFSS foods), many of these policies have a solid evidence base to show their effects on the food environment and consumer behaviour. For example, a systematic

review of real-world sugary drink taxes found that a 10% tax is associated with about a 10% reduction in sugary drink purchases. Data from Chile — the first country to implement a comprehensive package of policies, including mandatory front-of-package warning labels, strict marketing restrictions, and bans on in-school sales and promotion of HFSS foods — have shown that the policies reduced nutrients of concern in the food supply, improved parents' ability to identify unhealthy foods, reduced children's unhealthy food marketing exposure on television by 73% (ref. 14) and reduced purchases of unhealthy foods, ranging from 16% for saturated fat to 38% for sugar. In Brazil, the National School Feeding Program requires that 75% of food procured for schools be unprocessed or minimally processed and that 30% of foods procured come from family farms, ensuring that the food children receive at schools is of sufficient quality. Although few countries have yet explicitly targeted UPFs, in 2023 Colombia implemented a 20% tax that will increase the price of most UPFs (that is, those high in sugar, sodium, and saturated fat) by 2025, from 15% now. Taken together, these policies demonstrate that comprehensive policy action can create meaningful improvements in the food environment to support healthier choices. The next step will be to see how these policies specifically translate to curbing increases in UPF intake.

A key issue is understanding why UPFs are so popular. To be the most effective, advocates and policymakers wanting to promote healthier diets must be mindful of other constraints that affect food choice, including limitations on people's time to shop and prepare food, particularly women who remain the primary food preparers across the globe. Price remains a critical factor for many people, particularly those with low incomes, and using policy tools to reduce demand for UPFs will only go so far if people also cannot afford to purchase healthy foods. For example, after Chile's Law of Food Labeling and Marketing was implemented, during a period of global food inflation in 2021, mothers reported that they liked, understood and used the warning labels, but that they also felt unable to purchase healthy choices (that is, foods without the labels) because they could not afford them. At the same time, climate change is expected to increasingly disrupt food and water supplies, potentially reducing availability of fresh, local foods and increasing demand for shelf-stable, transportable products that may be ultra-processed. The Chilean government is now working to address some of these issues by developing a healthy food incentive programme that would distribute financial benefits to low-income families to purchase seasonal produce at local farmers markets in accordance with their dietary guidelines. Redemption of benefits at local farmers markets is one way to support local and regional producers by expanding their customer base and can create multiplier effects for the local economy. Indeed, effective deceleration of the global transition to UPFs will require an intersectional, whole-of-food-systems approach that recognizes and addresses factors such as poverty, time, gender, the environment, livelihoods and structural racism to make it possible for people to access, afford and choose healthier options. The hyper-palatability of UPFs not being matched by real food is another challenge for reconditioning tastes and preferences.

In conclusion, the rapid acceleration of LMICs to a landscape dominated by UPFs, including sugary drinks, along with accompanying high rates of obesity and NCDs, requires urgent action in the form of public policy. Additional research on the unique biological and psychological pathways of UPFs in the body can help refine future policies and interventions. In the meantime, policies such as taxes, marketing restrictions and mandatory front-of-package warning labels can help consumers readily identify unhealthy foods and discourage their purchase, whereas policies such as school feeding programmes and healthy food subsidies for the poor can help ensure that all people can access and afford healthy foods.

Barry Popkin [1,2] ✉, **Shu Wen Ng** [1,2] **& Lindsey Smith Taillie**[1,2]
[1]Global Food Research Program, Carolina Population Center, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA.
[2]Department of Nutrition, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA.
✉e-mail: popkin@unc.edu

Published online: 10 March 2025

References

1. Popkin, B. M. et al. *Lancet Diabetes Endocrinol.* **9**, 462–470 (2021).
2. Monteiro, C. A., Moubarac, J. C., Cannon, G., Ng, S. W. & Popkin, B. *Obes. Rev.* **14**, 21–28 (2013).
3. Poore, J. & Nemecek, T. *Science* **360**, 987–992 (2018).
4. Popkin, B. M. & Hawkes, C. *Lancet Diabetes Endocrinol.* **4**, 174–186 (2016).
5. DiMeglio, D. P. & Mattes, R. D. *Int. J. Obes. Relat. Metab. Disord.* **24**, 794–800 (2000).
6. van Tulleken, C. *Ultra-Processed People: Why We Can't Stop Eating Food that Isn't Food* (Knopf Canada, 2023).
7. Gearhardt, A. N. & DiFeliceantonio, A. G. *Addiction* **118**, 589–598 (2023).
8. Popkin, B. M., Miles, D. R., Taillie, L. S. & Dunford, E. K. *Lancet Reg. Health Am.* **32**, 100713 (2024).
9. Ercin, A. E., Aldaya, M. M. & Hoekstra, A. Y. *Water Res. Manag.* **25**, 721–741 (2011).
10. Baker, P. et al. *Obes. Rev.* **21**, e13126 (2020).
11. Zancheta Ricardo, C. et al. *Front. Nutr.* **9**, 1046463 (2022).
12. Popkin, B. M., Corvalan, C. & Grummer-Strawn, L. M. *Lancet* **395**, 65–74 (2020).
13. Hall, K. D. et al. *Cell Metab.* **30**, 67–77.e3 (2019).
14. Dillman Carpentier, F. R. et al. *Int. J. Behav. Nutr. Phys. Act.* **20**, 62 (2023).

Competing interests

The authors declare no competing interests.

Additional information

Peer review information *Nature Food* thanks Cherie Russell and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.