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Ultra-processed foods' impacts on health

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Ultra-processed foods and beverages increase significantly the risks of obesity, and other noncommunicable diseases, and most causes of mortality, while reduced consumption has significant effects on health and well-being

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Executive Summary

Ultra-processed foods (UPFs) are a heterogenous category of processed foods. Processed food is food that is altered from its natural state, such as freezing; drying; milling; canning; mixing; or adding salt, sugar, fat, or other additives. Here we define ultra-processed foods as multi-ingredient, industrially formulated mixtures. UPFs are formulated mixtures highly processed to the extent that they are no longer recognizable as their original plant or animal sources. Most are manufactured to be ready to eat or ready to heat, requiring no preparation before quick, easy consumption.

A substantial factor affecting overweight/obesity has been a major shift in the types of ready-to-eat, ready-to-heat, processed, and packaged foods and beverages retailers sell. This has been particularly important in Latin America and the Caribbean, where we have documented regional food system changes related to overweight/obesity. This is now a global trend and problem.

More profoundly, research is establishing a solid link between the move from real foods or minimally processed foods to UPFs and overweight/obesity and many diet-related noncommunicable diseases (NCDs). A team of US National Institutes of Health (NIH) researchers in 2019 conducted an excellent random controlled trial with a cross-over design, so each person was his or her own control. They fed normal-weight adults a real food diet for two weeks and a diet of ultra-processed foods for two weeks with half of the group starting with a real food diet and the other half with a UPF diet. When fed the real food the adults lost 0.9 kilograms, but when fed the ultra-processed food they gained 0.9 kilograms. They also showed a significant increase in risks of many NCDs after consuming the ultraprocessed diet. This NIH work was amplified by several subsequent papers in the British Medical Journal and other major health and nutrition journals. Each showed that higher UPF consumption was linked with higher risks of total mortality, cancer and cardiovascular mortality, diabetes, and many other NCDs.

Combinations of approaches to reduce UPF consumption work best. Fiscal policies that tax UPFs (booth food and beverages) will be most impactful in reducing consumption if the tax rate is high, ideally a minimum of 20%. The second key regulatory option is to use nutrient profiling models to create front-of-the-package labels (FOPLs). When designed as a warning label clearly identifying UPFs, FOPLs can be useful in executing school bans, marketing bans, and other fiscal policies. Chile is the best example of a country's success with warning labels that identify UPFs, in Chile's case those high in added sugar, saturated fat, or sodium and, for foods with those additives, energy density also.

1. What are processed foods?

Food processing is defined as any procedure that alters food from its natural state, such as freezing; drying; milling; canning; mixing; or adding salt, sugar, fat, or other additives (Dietary Guidelines Advisory Committee, 2010; US Food and Drug Administration and Department of Health and Human Services, 2011). Thus the US government's definition of *processed food*—any food other than a raw agricultural commodity—includes diverse foods ranging from frozen vegetables, dried fruits, and canned beans to whole wheat breads, breakfast cereals, prepared meals, candies, and sodas (Dietary Guidelines Advisory Committee, 2010; US Food and Drug Administration and Department of Health and Human Services, 2011). Because of this heterogeneity, researchers developed classification systems to subdivide processed foods into refined categories based on the complexity of processing, the physical and chemical changes resulting from processing, and the purpose of processing. Foods are classified into levels along a spectrum ranging from minimally processed to ultra-processed (Eicher-Miller, Fulgoni and Keast, 2012; International Food Information Council Foundation, 2010; Monteiro *et al.*, 2011; Slimani *et al.*, 2009).

Most nutritionists and public health scholars have accepted C. A. Monteiro's food classification, the most commonly used, as the global standard (Monteiro *et al.,* 2017; Poti *et al.*, 2015). Poti *et al.* (2015) provide the most detailed interpretation of Monteiro's classification. Their layout includes several million foods, linked with nutrition fact panel data, and ingredient databases to use the NOVA system to also categorize all bar-coded items with convenience status (e.g., ready to eat or ready to heat). This is presented in Appendix Table 1.

Here we define *ultra-processed foods* as multi-ingredient, industrially formulated mixtures (Monteiro, Cannon, *et al.,* 2017; Shewfelt, 2009).

Food processing can help ensure a safe, diverse, abundant, and accessible food supply (Floros *et al.,* 2010). However, the current state of research shows that excessive consumption of ultra-processed food might contribute to poor dietary quality and obesity (Monteiro *et al.,* 2011; Mozaffarian *et al,* 2011; Slimani *et al.,* 2009). In addition, many ultra-processed foods are manufactured to be ready to eat requiring no preparation before quick, easy consumption (Harris and Shiptsova, 2007). Researchers hypothesize that convenience foods disrupt satiation/satiety signaling by encouraging a rapid eating rate and eating while distracted (e.g., watching television) (Appelhans *et al.,* 2012; de Graaf, 2012; Robinson *et al.,* 2014; Robinson *et al.,* 2013; Viskaal-van Dongen, Kok and de Graaf, 2011).

2. Current knowledge on ultra-processed foods' impacts on health

Ultra-processed foods in the global diet

A substantial factor affecting overweight/obesity has been a major shift in the types of ready-to-eat, ready-to-heat, processed, and packaged foods and beverages available for consumption (Poti *et al.,* 2015). This has been particularly important in Latin America and the Caribbean, where Popkin and Reardon have documented regional food system changes related to overweight/obesity (Popkin, 2018). The last 60 years have seen a revolution in food science and manufacturing of highly processed foods, resulting in an increase of ultra-processed foods availability. The proportion of calories obtained from these foods—which include additives that enhance flavors and scents and are high in added saturated fat, added sugar, and added salt—saw explosive growth first in high-income countries in 1970–2000, then in Latin America in the 1990s with modern retailing, and now across all remaining low- and middle-income countries (Canella *et al.,* 2014; Cediel *et al.,* 2017; Monteiro *et al.,* 2011; Monteiro *et al.,* 2013; Moubarac *et al.,* 2014; Martínez Steele *et al.,* 2016).

Over the last 25 years, the availability and sales of these ultra-processed foods have increased rapidly across low- and middle-income countries and all regions of the world, and a growing set of studies is measuring this shift (Canella *et al.,* 2014; Cediel *et al.,* 2017; Monteiro, *et al.,* 2017; Monteiro *et al.,* 2013; Moubarac *et al.,* 2014; Martínez Steele, *et al.*, 2017). More profoundly, research is establishing a solid link between the move from real foods which are unprocessed or minimally processed to ultra-processed foods and overweight/obesity and many nutrition-related noncommunicable diseases (NCDs).

Ultra-processed foods' impacts on dietary intake, obesity, and NCDs

The rapid growth in sales of ultra-processed foods in low- and middle-income countries greatly threatens to increase overweight/obesity and undernutrition, because infants are increasingly fed these products. In addition, studies are beginning to associate ultra-processed foods with reduced length-for-age (Pries *et al.,* 2019). The Pries *et al.* 2019 study is the only one linking infant consumption of any ultra-processed food aside from infant formula, which fits into a different category but is also ultra-processed. We need longitudinal studies on cohorts with more recent full dietary intake data to reflect the shift in diets toward ultra-processed foods, which infants globally are consuming increasingly (Feeley *et al.,* 2016; Pries, Filteau and Ferguson, 2019; Pries, *et al.,* 2016; Pries, *et al.,* 2016; Pries *et al.,* 2019; Vitta *et al.,* 2016).

A team of US National Institutes of Health (NIH) researchers in 2019 conducted a random controlled trial with a crossover design, so each person was his or her own control. They fed normal-weight adults a diet of real food for two weeks and a diet of ultra-processed foods for two weeks. When fed the real food the adults lost 0.9 kilograms, but when fed the ultra-processed food they gained the same 0.9 kilograms. Each group started with one diet regimen and then shifted to the other (Hall, 2019). This NIH trial is important as up to this period all the studies discussed below were observational and therefore had focused on subsequent health risks for people according the amount of ultra-processed foods in their diet. Although these studies were controlled for a large list of potential confounders, such as physical activity and smoking, residual confounding never can be discarded. The NIH study put all subjects in a controlled food environment for a month. The researchers provided the two groups foods with the same distribution of fiber, protein, carbohydrates, fat, and total energy. However, while ultra-processed beverages can lower energy density and total energy, all ultra-processed foods are higher in energy density than real food. The two groups were allowed to eat *ad libitum* or the amount they wanted. As a result, the same individuals consumed 500 kilocalories more when they were in the ultra-processed food group than when they were in the real food group, which is important. Whether the mechanism involved is hyper palatability or energy density or both requires further study.

This NIH work was amplified by several papers that came out two weeks later in the British Medical Journal that looked at two large European cohorts and showed a strong positive relation between ultra-processed foods and cardiovascular disease and all-cause mortality (Fiolet *et al.,* 2018; Lawrence and Baker, 2019; Rico-Campà *et al.,* 2019; Srour *et al.,* 2019). A large number of studies published earlier reported longitudinal data from children and adults that associated ultra-processed food intake with increased NCD risk (Adjibade *et al.,* 2019; Costa *et al.,* 2019; Cunha *et al.*, 2018; Fiolet *et al.,* 2018; Gómez-Donoso *et al.,* 2019; Kim, Hu and Rebholz, 2019; Mendonça *et al.,* 2017; Mendonça *et al.,* 2016; Rauber *et al.*, 2015; Rauber *et al.,* 2018; Rico-Campà *et al.,* 2019; Rohatgi *et al.,* 2017; Sandoval-Insausti *et al.,* 2019; Schnabel *et al.,* 2019; Srour *et al.,* 2019; Vandevijvere *et al.,* 2019).

3. Impacts of regulations on ultra-processed food consumption

Globally most regulations focus on either fiscal policies or front-of-the-package labels (FOPLs). Nevertheless, some countries have focused on healthier eating in schools, and several have started to address marketing of ultra-processed foods directed toward children (Popkin, 2018; Shekar, 2019). These policies are discussed below in the context of reducing consumption of ultra-processed foods high in added sugar, added saturated fat, or added sodium or ultra-processed foods with high energy levels per 100 grams, since these elements have the strongest scientific basis.

Fiscal policies

To date the most widespread fiscal policies have put taxes on sugar-sweetened beverages (SSBs), and at this point, over 42 countries have this type of taxes. In the Americas these taxes have been based on volume (Figure 1: Sugary drinks taxes in Americas). For example, Mexico's tax, approximately 10% [one Mexican peso per liter on any nonalcoholic drink with added sugar] (Colchero, *et al.,* 2016; Colchero, *et al.,* 2017). Chile raised the tax on SSBs with more than 15 grams of sugar per 240 milliliters from 13% to 18% (Caro *et al.,* 2018). Several Caribbean islands have implemented similar small, incomplete taxes (Alvarado *et al.,* 2019). Globally only the United Kingdom (UK) and South Africa have instituted taxes that include a tier that is not taxed. The UK's has three tiers in addition to no tax on low-sugar products, and South Africa taxes products per gram of sugar. Most of these taxes exclude dairy products and 100% fruit juice, but the latter is increasingly considered for taxation, as the health impact of 100% fruit juice is comparable to that of SSBs. Increasingly countries are now including taxes on milk products with added sugar.
Only a few countries tax nonessential foods. Hungary and Mexico are the two most prominent, both countries taxes a subset of foods that the government denoted as unhealthy. The Mexican government taxes energy-dense foods with more than 275 calories per 100 grams at 8% of the price, and evaluations show that this tax has had an impact on nonessential food purchases equivalent to the tax level (Batis *et al.,* 2016; Taillie *et al.,* 2017). Similarly, the Hungarian tax adopted in 2012 applies to the sugar, caffeine, and salt contents of various categories of ready-to-eat foods and drinks, including energy drinks, which youths widely consumed. One econometric analysis using broad food and beverage categories from household expenditure data in Hungary found a 3.4% decrease in purchases of taxed processed food and a 1.1% increase in unprocessed food purchases (Bíró, 2015). Other initial reports suggest a much larger 27% decline in sales of taxed foods and extensive reformulation of ultra-processed food (WHO Regional Office for Europe (Nutrition Physical Activity and Obesity Programme), 2015).

The fiscal policies show two major gaps. To date no country has used a systematic approach to identify all ultra-processed foods and beverages rather than taxing the entire class of items. Which could be done with Chile's nutrient profiling model or a similar one (Corvalan *et al.,*

2019; Labonté *et al.,* 2018; Pan American Health Organization, 2016). Also no country has explored using the revenue from taxes on unhealthy ultra- processed foods to subsidize purchases of healthy foods (e.g., legumes, fruits, vegetables).

Figure 1: Sugary drink taxes in America
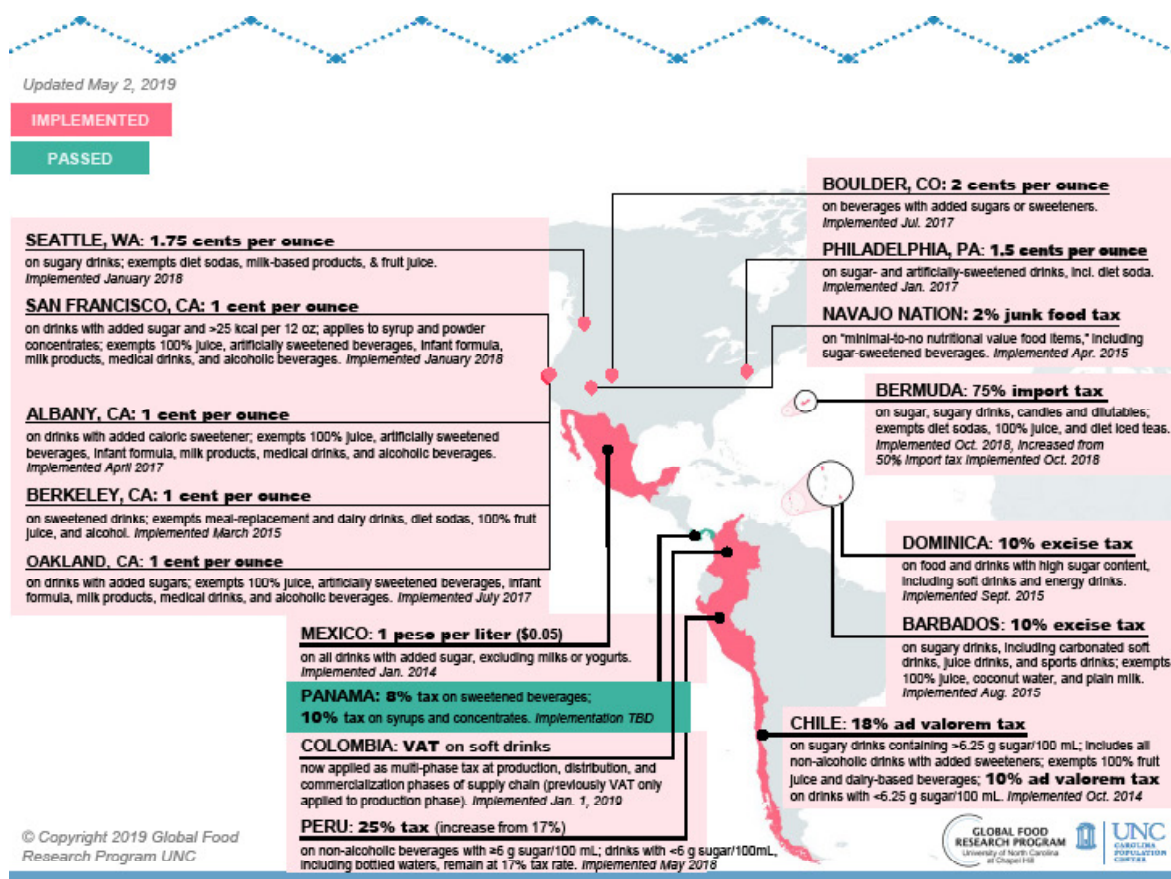
Front-of-the-package labeling policies

Many countries have used this option to encourage healthy eating and reduce the risks accompanying unhealthy nutrients (Figure 2). The key nutrients addressed have been sugar, saturated fat, and sodium. Some countries have also focused on energy density in unhealthy foods and beverages. There are several types of labelling: Healthy food options logos, Warning labels systems, Guidelines of Daily Allowance, Traffic label systems and Nutriscore.

The long history of FOPLs began in 1989, when the Swedish government established the **Keyhole** logo to designate healthy food options and set nutrition criteria for its use. Sweden, Denmark, and Norway launched the Keyhole logo as a common Nordic label on 17 June 2009, and Lithuania followed in 2013. The Keyhole logo helps consumers choose products that contain less fat, salt, and sugar. Its use is voluntary, but products must conform to the nutrition criteria, which are identical among participating countries. The program set stricter criteria in 2016 (Becker *et al.,* 2015; Hawley *et al.,* 2013; Nestle, 2018; U.K. Department of Health, 2013; World Cancer Research Fund International, 2019).

The evidence that positive logos have an impact on food purchasing behavior is minimal. One study reported that the **Choices International** program has a small impact on reformulation (Roodenburg, Popkin, and Seidell, 2011; Vyth *et al.,* 2012). Another study looked at the impact of the Choices logo that the Netherlands required and the tick type of logo in Denmark and reported that only the Choices logo was linked with increases in nutritional food purchases of 10% in one group (Smed, Edenbrandt and Jansen, 2019). There is a large number of random controlled trials that show that simpler FOPL's work best (Ares *et al.,* 2018; Feunekes *et al.*, 2008; Hamlin, McNeill and Moore, 2014; Roodenburg, Popkin and Seidell, 2011; Wartella, Lichtenstein and Boon, 2010).

In 1998 the food industry initiated the **Guidelines of Daily Allowance (GDA)**, a voluntary collaboration between the UK government, the food industry, and consumer organizations. Subsequently the Grocery Manufacturers of America and food industry lobbies in many other countries pushed it. Several governments **allow use of the GDA's and only Mexico requires it but that law will be shifted to a warning label**. The GDA's is the laxest FOPLs. They list five key nutrients, energy, fat, saturates, sugar, and salt, and indicate the percentage of the recommended daily value of each per serving and the absolute amount per serving. Dozens of random controlled trials report that their impact is negligible, and no study has found that they positively affect food purchases, while others have found GDAs ineffective and difficult to understand:

> o Qualitative research in Mexico found that GDAs were the hardest to understand and least accepted FOPL due to the technical terms and lack of comprehensive nutrition information (De la Cruz-Góngora *et al.,* 2017).

> o Consumers require more time to assess GDAs and have much less success understanding them than other labeling approaches (Bialkova *et al.,* 2014; Siegrist, Leins-Hess and Keller, 2015).

> o GDAs do not reduce consumption of unhealthy products (Boztuğ *et al.*, 2015).

> o All nonindustry-funded studies comparing GDAs with other systems (traffic lights, Nutri-Score, Choices, Health Star Rating, and Chile's and Brazil's warning labels) show that GDAs are the least effective at encouraging consumers to make healthier choices (Ducrot *et al.,* 2016; Ducrot *et al.,* 2015; Julia *et al.,* 2017; Siegrist *et al.,* 2015).

> o Studies in Australia and New Zealand found that GDAs (locally referred to as Daily Intake Guides) were less preferred by consumers and less effective at helping them discriminate between healthy and unhealthy products compared to traffic lights and Health Star Rating labels (Pettigrew *et al.,* 2017; Talati *et al.,* 2017).

> o Studies using eye-tracking technology have found that GDA labels are less effective at getting consumers' attention and thus less able to help consumers identify whether a product is unhealthy compared to warning labels (Centurión, Machín and Ares, 2019; Popova *et al.,* 2019).

The UK government was the first to use the **Traffic label system** (Hawley *et al.,* 2013; Health, 2013; Sacks *et al.,* 2011). A red light indicates a high level of that nutrient, an amber light a medium level, and a green light a low level according to the nutrition criteria their Food Standards Agency set. Evaluations have found no evidence that traffic lights have a positive impact on food

purchases. The traffic light system was first introduced as a voluntary system in the UK and is now implemented also in Ecuador and South Korea (Freire, Waters and Rivas-Mariño, 2017; Hawley *et al.*, 2013).

The **Nutriscore** is a completely untested system but has attracted a great deal of attention. It was developed to be consumer friendly and has had the support of most major global food companies. This system classifies food and beverages according to five categories of nutritional quality, indicated via a color scale ranging from dark green to dark red, along with a letter from A to E with A equal to dark green. It is based on 100 grams and positive nutrients (fiber, protein, fruit and vegetables) and negative (energy, saturated fatty acids, sugars, salt). They use a complex non-transparent scoring system. It was introduced as a voluntary system in France in 2016, and after European Commission approval in 2017, it was required.

Chile was the first country to use the warning label approach to delineate ultra-processed or heavily processed foods by focusing on added sugar, added sodium, and added saturated fat, and for foods with added sugar or added saturated fat it also included an energy density cutoff (Corvalan *et al.*, 2019; Reyes *et al.*, 2019). This warning label system is rapidly spreading globally as countries learn of the impact of the Chilean law on purchase of ultra-processed food and beverages. As we discuss below, Chile used this nutrient profile model in an array of linked policies. Over four years the country instituted three phases of increasingly stringent cutoffs and identified those foods with a black stop sign warning label. Chile is the first country to demarcate in forthcoming papers the impacts of this warning label on both industry reformulation and significant declines in purchases of regulated foods and beverages. In addition, this policy seems to be linked with potential eating norm changes (Correa *et al.*, 2019). Journals are reviewing the research.

- Research shows significant reformulation of foods and beverages high in added sodium and added sugar, and has found reductions of saturated fat only in selective food groups (Reyes *et al.,*2019).

- Research indicates a reduction of 25% in purchases of regulated SSBs (Taillie LS, 2019).

Israel, Peru, and Uruguay have implemented the warning label logo. Few countries have used any other FOPL as a mandatory system. Canada's legislature has approved the warning label law and it is waiting for PM Trudeau's signature. Over the next year, Mexico and Brazil will implement it, and a number of other countries are considering it. In all countries, the warning label has faced food industry opposition.

Figure 2: Countries with mandatory interpretive labels on packaged foods

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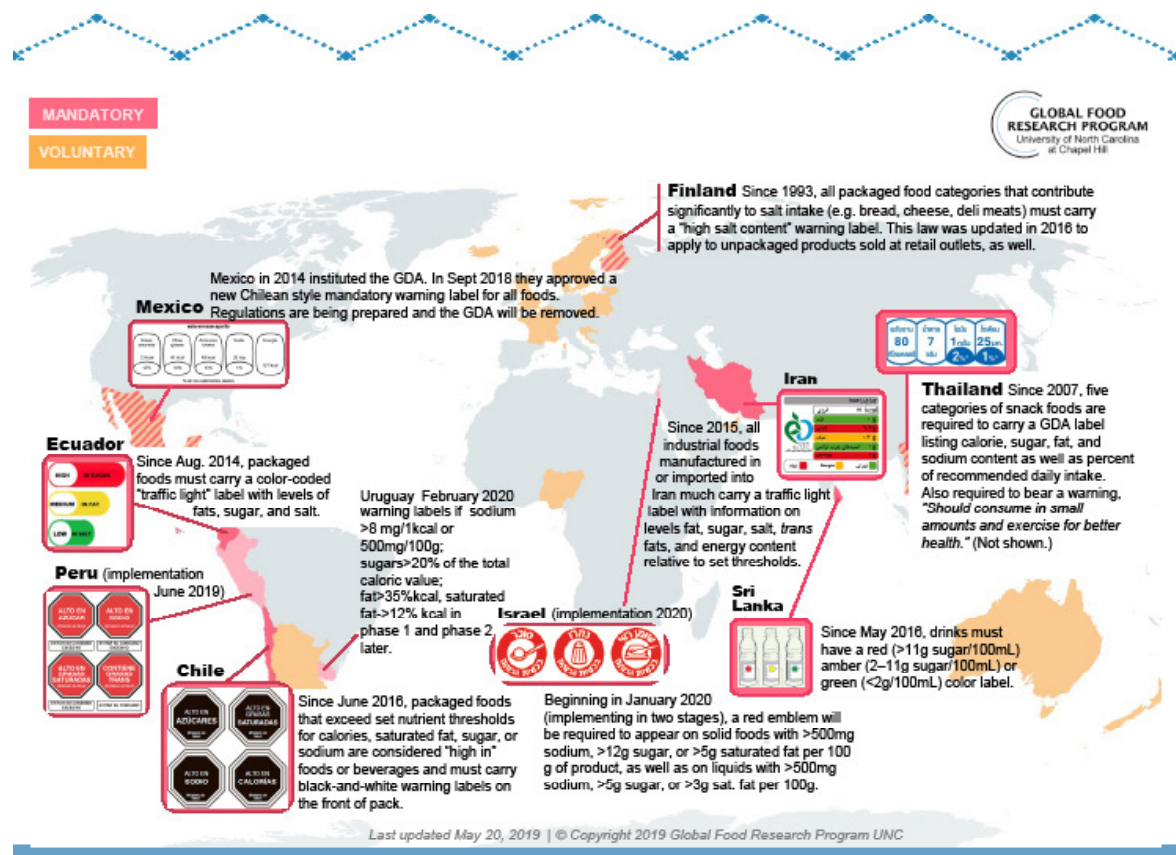
Marketing controls

Children are exposed every day to food marketing where they live, learn, and play—on TV, at school, at sports practice, in stores, at the movies, on mobile devices, and online (Federal Trade Commission, 2012; Harris *et al.,* 2009; McGinnis, Gootman and Kraak, 2006; Palmer and Carpenter, 2006). In the United States children ages 2 to 11 view roughly 13 ads a day for foods, beverages, and restaurants on TV (Rudd Center For Food Policy and Obesity, 2014). A 2019 study of TV advertising in 22 countries found on average four times more ads for unhealthy foods and drinks than for healthy ones and 35% more unhealthy food ads during children's peak viewing times (Kelly *et al.,* 2019). While TV has historically been the medium of choice to reach children, marketing via newer online, mobile, and social media has exploded in recent years, offering marketers more tools to target young audiences (Cheyne *et al.,* 2013; Common Sense Media, 2014; McGinnis *et al.,* 2006; Montgomery and Chester, 2009). The majority of promoted food products are calorie dense and nutrient poor with added sugar, saturated fat, and sodium well above recommended levels (e.g., sugary breakfast cereals, soft drinks, candy, salty snacks, and fast foods) (American Heart Association, 2016; Cairns *et al.,* 2013; Federal Trade Commission, 2012; Harris, Pomeranz, *et al.,* 2009; Kelly *et al.,* 2010; Matthews, 2008; McGinnis et al., 2006; Palmer and Carpenter, 2006; World Health Organization, 2013, 2016). Children are extremely vulnerable to food marketing. Developmentally, they are highly impressionable, cannot yet recognize advertising intent, lack nutritional knowledge, and are motivated by immediate gratification rather than long-term consequences (Harris, Brownell and Bargh, 2009; McGinnis *et al.*, 2006; Swinburn *et al.,* 2011).

Chile is the only country that has systematically banned marketing of ultra-processed foods to children (Corvalan *et al.,* 2019) and that included banning characters on packages of regulated foods (Mediano Stoltze *et al.,* 2018). The marketing ban carried over to schools. In June 2019 the Chilean government initiated a total ban on marketing of all regulated phase 3 foods from 6 am to 10 pm, and during other hours all marketing of regulated foods is required to include a warning message. Initial evaluations of the child marketing ban show a significant reduction in children's exposure to ads, but the total advertising did not decrease because promoters shifted to other TV programs (Carpentier, 2019; Correa *et al.,* 2019).

Other countries have limited or voluntary bans on marketing to children (Figure 3). Few have been evaluated, and those that have been show minimal impacts. Effective food marketing regulations should address the types of foods and beverages regulated, the channels through which they are marketed (e.g., television, digital media, schools, etc.), and the audiences reached. The key concepts for developing effective regulations follow.

- Partial measures are ineffective as ways to avoid restrictions through alternative paths can be found to achieve the same reach to consumers (Galbraith-Emami and Lobstein, 2013; Swinburn *et al.,* 2008).

- Effectiveness of industry self-regulation is questionable. Provisions are often weak, participation is voluntary, and enforcement and penalties are not strong enough to ensure compliance (Galbraith-Emami and Lobstein, 2013; Kelly *et al.,* 2019; Swinburn *et al.,* 2008). For example, studies have found that countries with voluntary industry self-regulation have more TV advertising for unhealthy foods during children's peak viewing times than countries with no policy at all (Kelly *et al.,* 2019).

- Rigorous enforcement is critical. Compliance is maximized only if marketers are likely to be caught and face meaningful penalties (Galbraith-Emami and Lobstein, 2013; Swinburn *et al.,* 2008; World Health Organization, 2012).

The Chilean marketing ban is the most complete and should be a starting point for any future laws in the Americas. What has been and will be learned in Chile shows other countries the wisest paths forward.

Figure 3: Countries with statutory regulations or voluntary industry self-regulations on food marketing to children

National or regional statutory regulation

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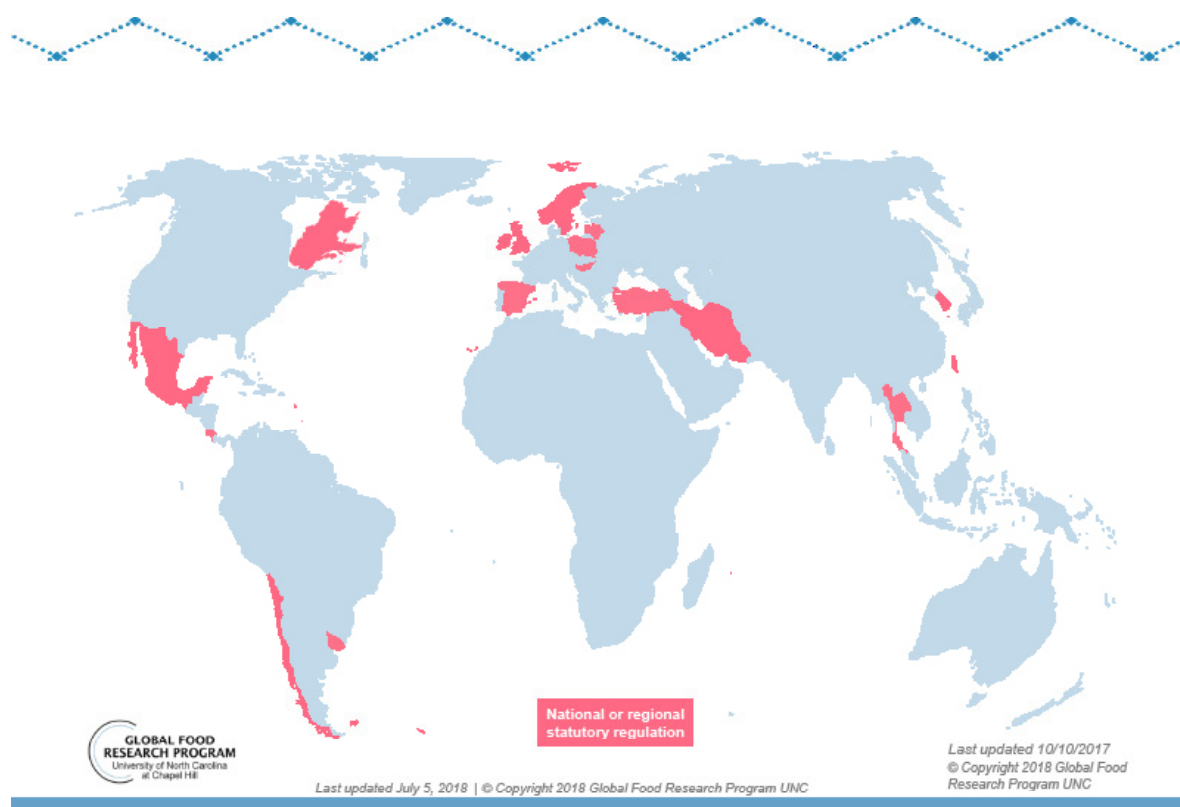
School nutrition

School nutrition focuses most commonly on healthy meals or a total ban on selling and marketing ultra-processed foods and beverages, especially SSBs. Schools are meant to provide a healthy environment for children's minds and bodies. As places of education, schools have an opportunity to encourage healthy eating both inside and outside the school environment. Providing and promoting unhealthy foods in and around schools contributes to poor nutrition. The standards for school vendors should mirror those of school meals. Such standards have been shown to decrease consumption of sugary drinks and unhealthy snacks in and out of school (Micha *et al.,* 2018). A districtwide policy that banned all sugary drink sales in Boston, Massachusetts, public schools led to a significant reduction in students' total consumption of sugary drinks (Cradock *et al.,* 2011). In 2012 Massachusetts implemented nutrition standards for competitive foods sold in schools statewide that has also been associated with significant decreases in students' sugar consumption both during and after school (Cohen *et al.,* 2018). Seven years after Brazil implemented its first national law regulating sales of unhealthy foods in schools, nearly 70% of school vendors stopped selling fried snacks, sodas, ultra-processed popcorn, candies, lollipops, chewing gum, and packaged snacks (Gabriel *et al.,* 2009).

Restrictions on marketing of unhealthy foods on school grounds are important. Heavy promotion of unhealthy foods and beverages on school grounds through direct advertising, branding, event sponsorships, and contractual vending and food service agreements reinforce unhealthy choices and undermine messages about healthy eating (Harris and Fox, 2014; McGinnis *et al.,* 2006; Story and French, 2004). More importantly, it encourages students to become loyal consumers of unhealthy food and beverage brands (Connell, Brucks, and Nielsen, 2014; Harris *et al.,* 2009).

Chile, Poland, Spain, Uruguay, and certain municipalities in Brazil have successfully implemented restrictions on marketing and promotion of products that do not meet nutrition standards for preschools and primary and secondary schools (Gabriel et al., 2009; World Cancer Research Fund International, 2018). Convenience stores and fast food outlets clustered near schools provide easy access to cheap unhealthy food, which is often displayed prominently with attention-grabbing advertising (Barquera, et al., 2018; Gebauer and Laska, 2011; Kelly, et al., 2008; Moodley, et al., 2015). A healthy school food policy should restrict marketing and junk food sales in close proximity to schools. Evidence shows that less exposure to unhealthy foods near schools reduces weight gain, while exposure to unhealthy foods near schools increases weight gain. A survey of food vendors within 100 meters of elementary schools in Mexico found that children attending schools with the highest concentrations of mobile food vendors had higher BMIs (Barrera, et al., 2016).

Several countries have implemented limited policies regarding marketing and selling of ultra-processed foods in schools, but again Chile has instituted the most progressive policy of banning all ultra-processed foods and beverages and any marketing from schools (Corvalan et al., 2019). This effort appears to be part of the country's efforts to shape healthy food norms for children (Correa, et al., 2019a).

Summary of policy options

A large number of countries have instituted fiscal food policies, mainly SSB taxes, and a few also tax ultra-processed foods. Solid evidence indicates that these taxes work. However, it is too early to know if a tiered tax like the one the UK has instituted, a tax on grams of sugar, or a volume tax is most effective. It is clear is that SSBs need to be taxed at 20% or higher to have a true impact on consumption and the risks of overweight/obesity and nutrition-related NCDs.

At the same time a nutrition profile model that identifies the unhealthiest ultra-processed foods can be used across many domains, including fiscal policies, FOPLs and warning labels, marketing bans, and restrictions in schools. Chile's strong comprehensive policies are linked with significant overall changes in food purchasing and eating norms. Science tells us that FOPLs have the most immediate impact on purchases of ultra-processed foods. Moreover, this effort can be readily expanded to marketing, school nutrition, and fiscal policies.

Acknowledgements

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Appendix

Table 1: Category definitions and criteria for classifying foods and beverages based on degree of industrial food processing[1]

Category and Definition	Beverages	Fruit, vegetables, legumes	Meat/meat dishes/ eggs	Grain products	Dairy products	Fats/oils, sweets, other
LESS-PROCESSED UNPROCESSED / MINIMALLY PROCESSED Unprocessed / Minimally processed: Single ingredient foods with no or very slight modifications that do not change inherent properties of the food as found in its natural form[3]	Fresh plain[4] milk, coffee (whole or ground beans), bottled plain water, tea leaves or bags	Fresh, frozen, or dried plain fruit, vegetables, or legumes; plain nuts	Eggs; unseasoned[5] meat (refrigerated or frozen)	Whole-grain plain hot cereal, brown rice, popcorn kernels	Cream	Honey, herbs, spices, pepper
BASIC PROCESSED **Processed basic ingredients:** Single isolated food components obtained by extraction or purification using physical or chemical processes that change inherent properties of the food **Processed for basic preservation or pre-cooking:** Single minimally processed foods modified by physical or chemical processes for the purpose of preservation or pre-cooking but remaining as single foods	Unsweetened[6] fruit juice not-from-concentrate	N/A	Egg whites	Whole-grain[7] flour, whole-grain pasta	N/A	Oil, unsalted butter, sugar, pure maple syrup, salt
	Unsweetened fruit juice from-concentrate or frozen concentrate, dry milk, instant coffee	Unsweetened/unflavored canned fruit, vegetables, or legumes; unsweetened/unsalted peanut butter	Unseasoned canned meat	Refined-grain pasta, refined-grain flour, white rice, instant rice, plain refined-grain hot cereal	Sour cream, plain yogurt, evaporated milk	N/A
MODERATELY PROCESSED **Moderately processed for flavor:** Single minimally or moderately processed foods with addition of flavor additives for the purpose of enhancing flavor; directly recognizable as original plant/animal source	Sweetened/flavored[8] fruit or vegetable juice, tea, or soy milk; chocolate milk; cocoa mix	Sweetened/flavored canned, dried, refrigerated, or frozen fruit, vegetables, or legumes; jam; potato chips; frozen French fries; salted peanut butter; nuts with salt or oil	Seasoned refrigerated, frozen, or canned meat; smoked or cured bacon, ham, or seafood	Sweetened/flavored hot cereal, flavored pasta, flavored popcorn (microwaveable or pre-popped)	Cheese, sweetened/ flavored yogurt, sweetened condensed milk, whipped cream	Salted butter, flavored oil, seasoning salts
Moderately processed grain products: Grain products made from whole-grain flour with water, salt, and/ or yeast				Whole-grain breads, tortillas, crackers, or RTE cereals with no added sugar or fat		

	Examples within food groups[2]					
Category and Definition	Beverages	Fruit, vegetables, legumes	Meat/meat dishes/ eggs	Grain products	Dairy products	Fats/oils, sweets, other
ULTRA PROCESSED **Ultra processed ingredients:** Multi-ingredient industrially formulated mixtures processed to the extent that they are no longer recognizable as their original plant/animal source, and consumed as additions (condiments, dips, sauces, toppings, or ingredients in mixed dishes)	N/A	Tomato sauce, salsa, hummus, jelly	N/A	Bread crumbs/breading with refined grains or added sugar/fat	Creamer, whipped topping, dairy-based chip/veggie dip, cheese dip/queso, alfredo sauce	Margarine; mayonnaise; salad dressing; shortening; pancake syrup; artificial sweetener; baking chocolate; icing; ketchup, barbecue sauce, marinades, and other condiments; sauce/seasoning mixes
Ultra processed stand-alone: Multi-ingredient industrially formulated mixtures processed to the extent that they are no longer recognizable as their original plant/animal source, and not typically consumed as additions	Soda, alcohol, fruit drinks,[9] sports drinks, energy drinks, flavored waters, coffee beverages	Fruit snacks; gelatin fruit salads; chocolate- or yogurt-covered dried fruit or nuts; vegetable-based soups; frozen vegetables in sauce; onion rings; entrée garden salads; re-structured potato chips; tater tots, hash brown patties, re-formed French fries; RTH or instant potato dishes (mashed potatoes, stuffed baked potatoes); RTE potato salad; canned baked beans or beans with pork	Sausage; hot dogs; pressed/formed lunchmeats (bologna, salami) or ham; Spam; RTH meat dishes (meat loaf, crab cakes, buffalo wings, pot roast, barbecue); meat-based frozen meals (Salisbury steak); breaded meat (chicken nuggets, fish sticks); meat-based soups	Bread, tortillas, rolls, bagels, or RTE breakfast cereals with refined grains or added sugar/fat; pancakes, waffles, or biscuits (RTH, ready-to-bake, mixes); grain-based desserts (cookies, cake, pie, pastries; RTE, ready-to-bake, mixes); processed salty snacks (crackers, pretzels, tortilla chips, cheese puffs); frozen pizza; RTH or RTE grain-based dishes (burritos, sandwiches, pot pies); frozen or canned pasta dishes (lasagna, ravioli, spaghetti and meatballs); pasta- or rice-based frozen meals; boxed macaroni-and-cheese; instant rice/pasta dish mixes; noodle- or rice-based soups; stuffing mix	Ice cream, frozen yogurt, pudding (RTE and mixes), processed cheese, cheesecake	Candy, chocolate, popsicles, sorbet, gelatin (RTE and mixes), broth, bouillon

[1] Industrial food processing was defined as any procedure that alters food from its natural state and includes all processes and technologies that transform raw food materials and ingredients into consumer food products. Mutually exclusive categories of processing were defined based on the extent to which a food was altered from its natural state by industrial food processing and the purpose of these processes. Food processing was considered separately from product convenience. RTE, ready-to-eat; RTH, ready-to-heat.

[2] Food groups were defined broadly to classify all products into beverages or 10 mutually exclusive food groups. "Fruit, vegetables, and legumes" includes fruit/fruit products, vegetables/vegetable products, starchy vegetables/starchy vegetable products, and nuts/legumes. "Meat" includes beef, pork, poultry, and seafood.

[3] Fresh fruits and vegetables and fresh unseasoned meats were only included in our study if they were barcoded.

[4, 5, 6] "Plain," "unseasoned," and "unsweetened" indicate that the product contains no added sweeteners (natural or artificial), salt, flavors, fats, or oils.

[7] Whole-grain products were defined by the 2010 Dietary Guidelines for Americans criteria of primarily containing "whole-grain" wheat, rye, oats, corn, barley, or other grains labeled as "whole;" brown rice; buckwheat; bulgur; millet; oatmeal; popcorn; quinoa; or rolled oats.

[8] "Sweetened/flavored" indicates that the product contains added sweeteners (natural or artificial), salt, flavors, fats and/or oils.

[9] Fruit drinks are defined as beverages primarily composed of sugar or sweetener (as 1st or 2nd ingredients) with fruit juice or fruit juice concentrate as a lesser ingredient.