

# Appetite Self-Regulation: Environmental and Policy Influences on Eating Behaviors

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**Objective:** Appetite regulation is influenced by the environment, and the environment is shaped by food-related policies. This review summarizes the environment and policy research portion of an NIH Workshop (Bethesda, MD, 2015) titled “Self-Regulation of Appetite—It’s Complicated.”

**Methods:** In this paper, we begin by making the case for why policy is an important tool in efforts to improve nutrition, and we introduce an ecological framework that illustrates the multiple layers that influence what people eat. We describe the state of the science on how policies influence behavior in several key areas: the federal food programs, schools, child care, food and beverage pricing, marketing to youth, behavioral economics, and changing defaults. Next, we propose novel approaches for multidisciplinary prevention and intervention strategies to promote breastfeeding, and examine interactions between psychology and the environment.

**Results:** Policy and environmental change are the most distal influences on individual-level appetite regulation, yet these strategies can reach many people at once by changing the environment in which food choices are made. We note the need for more research to understand compensatory behavior, reactance, and how to effectively change social norms.

**Conclusions:** To move forward, we need a more sophisticated understanding of how individual psychological and biological factors interact with the environment and policy influences.

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## Introduction

As described in other articles in this issue, many determinants of appetite self-regulation occur at the individual level. However, the genetic, biological, and psychological factors examined in the preceding articles interact with the individual’s environment, and that environment is shaped by systems and policy decisions that have been made over time. In this context, we use the term “environment” broadly and posit that, historically, many forces have interacted to change the environment, most often without consideration of the impact on eating behaviors and health. Given the importance of early life experiences on the development of appetite regulation, and the predominance of the literature on policy and food environment influences in childhood, we focus here on food policies that have the potential to impact children’s ability to self-regulate appetite. As a key goal of public health efforts is to create environments that support healthy behaviors (1), it is critical to understand what has changed and why, and advocate for the most effective policies. Therefore, the aim of the present paper is to make the case for why policy is important, describe the state of the science on how policies influence behavior, identify gaps in knowledge, and propose novel approaches for multidisciplinary prevention and intervention strategies.

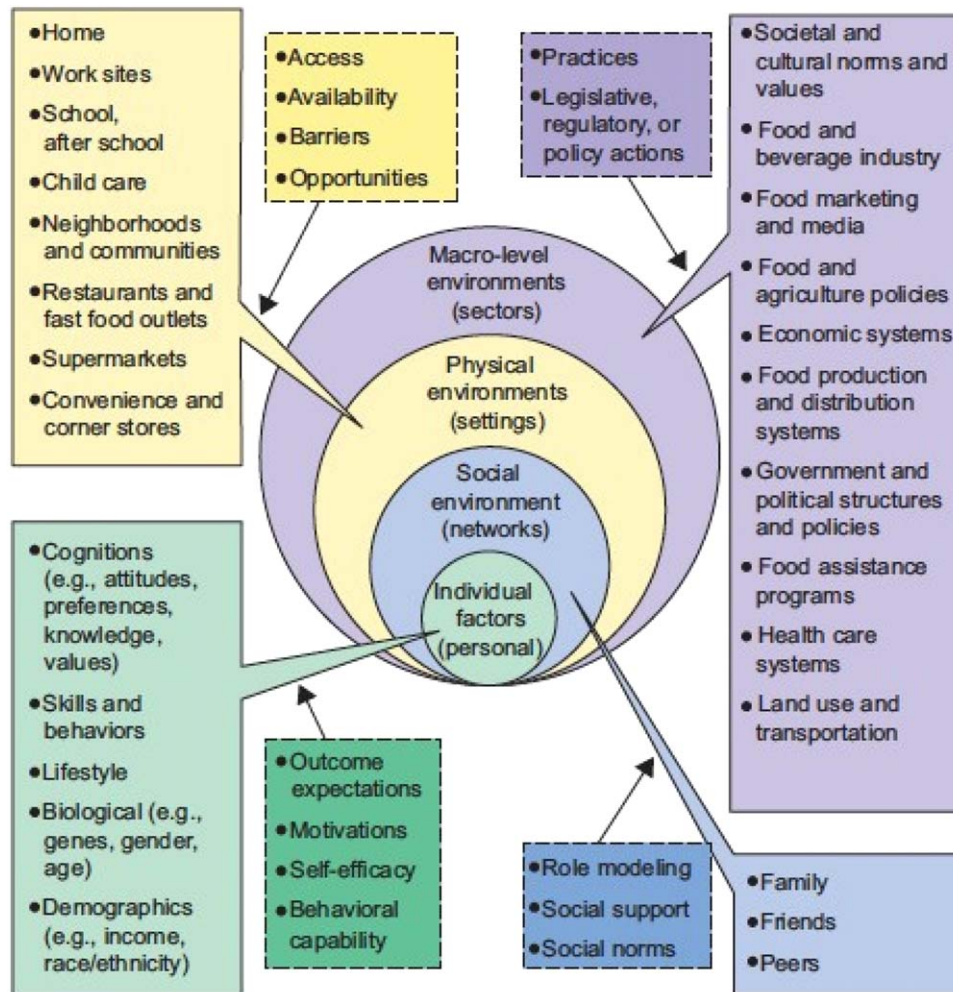
## Why Is Policy Important?

Historically, obesity has been considered an individual’s medical problem, and the primary response has been to provide treatment. Treatments range in intensity from self-help approaches and lifestyle intervention programs to the use of medical interventions including medication, devices, and bariatric surgery. As the rates of adult and childhood obesity climbed over the past three decades and children began suffering from diseases such as type 2 diabetes, the national conversation shifted from a medical model conceptualization of obesity to include a public health model. The medical model focuses on who is affected, what the causes are, and what can be done by the health care system to reduce individual suffering. The public health perspective asks how many are affected, whether the environment has changed to produce this shift in population health, and how government and the private sector can intervene to collectively solve this societal problem (2). Brownell coined the phrase “toxic environment” to capture the changes in the food and built environment that fueled the obesity epidemic (3). This theory about the underlying causes of the increase in obesity rates gained popularity, and obesity and public health scientists and advocates took on the task of highlighting how changes in schools, neighborhoods, the retail environment, and food marketing were now

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**Figure 1** An ecological framework depicting multiple influences on what people eat. Reprinted from Story et al. *Annu Rev Public Health* 2008;29:253-272 (4), with permission from Annual Reviews. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

potentially facilitating unhealthy dietary patterns and physical inactivity, particularly in our nation's youth.

An ecological model, depicted in Figure 1, emerged to explain the complex layers of influences on food intake and obesity (4). The nested layers include individual factors, social environments, physical environments, and macro-level environments. The model suggests that each of these layers interact with each other to produce the outcome of individual diet quality.

An illustrative example of how biology, the environment, and policy implementation interact is the change in consumption of milk and soda among adolescents over time. In the late 1970s, adolescent males consumed seven servings a week of soda and 15 servings a week of milk. By the mid-1990s, the relative prevalence had reversed to 21 servings a week of soda and only seven servings a week of milk. It is hard to argue that this change was due to an evolution in the genetic or biological preferences for soda versus milk; children likely thought that soda tasted better

than milk in the 1970s, and children continued to think soda tasted better in the 1990s. Examining changes in the typical adolescent environment leads to another hypothesis. In the 1970s, the only beverages in schools were milk and water, whereas by the late 1990s nearly all high schools had vending machines filled with soda and pouring-rights contracts with beverage companies for exclusive rights to sell their brands in schools (3). Another change is that in the 1970s youth saw advertisements on television shows that aired during "family hour" in the evening or on Saturday morning cartoons, but in the 1980s, child and adolescent exposure to marketing on television increased as a result of the fact that entire networks were created to appeal to youth, such as Nickelodeon and MTV. Therefore, we argue that the increase in soft drink consumption observed in adolescents between 1970 and 2000 was not driven by a decrease in children's capacity to self-regulate their consumption of high calorie beverages; rather, it was driven by changes in youth exposure to marketing and unhealthy school environments, which can be attributed to the commercial activities of the beverage industry and the lack of

**TABLE 1** Examples of authoritative bodies recommending or recognizing policy and environmental change strategies to improve diet and physical activity and to reduce or prevent obesity

Centers for Disease Control and Prevention (144)  
Institute of Medicine (11)  
National Physical Activity Plan (145)  
State, local, and school district governments  
US Surgeon General (146)  
US Department of Agriculture (USDA)  
US Department of Health and Human Services (147)  
White House Task Force on Childhood Obesity (148)  
World Health Organization (149)

federal or state policy to prohibit the sale of high-sugar beverages in schools.

To continue the above example, both the beverage environment and soda consumption have changed yet again since the turn of the century. In 2006, major soft drink companies pledged to stop direct marketing to children under 12 and joined the Children’s Food and Beverage Advertising Initiative (5). In 2014, sugared soda was finally completely removed from all schools in the nation as part of the Healthy Hunger Free Kids Act, the culmination of a decade of efforts to remove sugary drinks from schools through local and state policies. Throughout this same time period, soda consumption has been dropping about 1% a year, and in 2015 soda consumption fell to a 30-year low (6).

The current question is how best to reverse the changes that escalated toward the end of the 20th century and caused such dramatic damage to the health of Americans. Over the past 10 to 15 years, numerous authoritative governmental and quasigovernmental bodies have recognized the role that policy and environmental change strategies can play in effectuating population-wide behavior changes that could lead to improvements in diet quality and physical activity, and ultimately reduce and prevent obesity among children, youth, and adults (see Table 1 for examples of these organizations). While the specific strategies may vary, the common theme is that no one sector alone will be able to improve the obesogenic environment within which Americans live, work, and play. The food environment is influenced by governments, businesses (including the food and beverage industry, retail food outlets, and entertainment and recreational venues selling foods), schools, and through planning and zoning that influences the types of food outlets permitted in communities.

A wide range of policy strategies aimed at improving diet and reducing/preventing obesity have been adopted and studied in recent years (7-9), and there are a number of mechanisms through which these strategies can work. A recent review of evidence by Hawkes and colleagues (10) included a framework for understanding the theory of change and four mechanisms by which food policy actions might work to improve food environments and diet (Figure 2). Notably, the mechanisms identified by Hawkes et al. are consistent with the recommendations espoused by the Institute of Medicine (11). First, policy actions can provide an enabling environment for individuals, particularly in the early years of life, to learn and develop

healthy food preferences (e.g., establishing nutrition standards for child care centers that are aligned with the US Dietary Guidelines recommendations). Second, policy actions can be taken to improve access to and affordability of healthy foods (e.g., aligning school foods and worksite cafeterias with Dietary Guideline recommendations, making healthier options such as fruits and vegetables more affordable) or limit access to unhealthy foods (e.g., establishing moratoriums on fast food outlets within certain distances of schools). Third, policies adopted by governments, employers, and businesses can regulate the pricing, availability, and presentation of healthier options at points-of-purchase (e.g., placement of healthier options at checkouts, preferential pricing for water over sugary drinks). And, fourth, policies can stimulate a “food-systems response” (10) whereby one policy can lead to system-wide changes in the food system (e.g., mandatory labeling of trans fats or, alternatively, mandatory sodium reductions or portion size limits on snack foods sold in schools that can lead to industry-wide reformulation efforts or changes in demand on the part of large-volume retailers, which lead to concomitant changes in industry product formulation). In sum, policy changes are an effective and efficient way to transform the food environment, thereby impacting overconsumption of unhealthy foods and promoting population health.

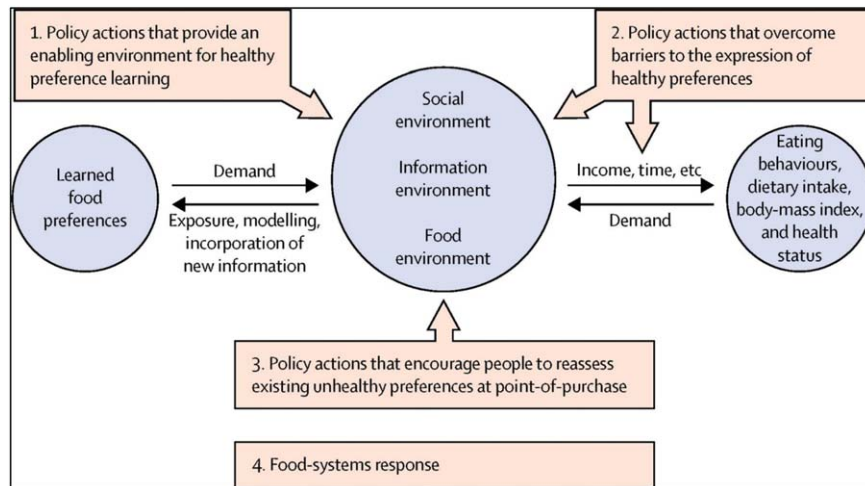
## State of the Science

Over the last decade there has been increasing scientific interest in measuring how the environment influences behavior and, in turn, how policies influence the environment. While not exhaustive, the following sections highlight some of the research and advocacy efforts addressing the federal food programs, schools, child care, food and beverage pricing, marketing to youth, and the power of behavioral economics, all of which can be expected to impact dietary self-regulation.

### Federal food programs

Federal food assistance programs play a prominent role in our economy, accounting for nearly 80% of spending in the 2014–2018 Farm Bill (12). These programs are an important driver in the food retail and agricultural economy while providing nutritious food for low-income families. Among the 15 federal food assistance programs, those with the greatest population reach include the SNAP Program (Supplemental Nutrition Assistance Program—formerly Food Stamps), WIC (Women, Infants, and Children), and the National School Lunch, Breakfast, and Summer Meals Programs. Smaller programs include the Child and Adult Care Food Program, commodity and disaster relief programs, and Farmers Market Nutrition programs. The National School Lunch Program is discussed below under school policies. Here, we will address WIC, SNAP, and SNAP-Ed (the educational component of SNAP), as these programs have been significantly tailored to meet the changing needs of the US population based on evidence compiled for the Dietary Guidelines.

The WIC program has demonstrated substantial population benefits in terms of lower infant mortality, reduced prematurity, and a reduction in low birth weight deliveries (13,14). As a consequence, the WIC program has been credited with a beneficial return on investment in terms of health care and Medicaid costs. The WIC program provides prenatal care and food vouchers through an Electronic



**Figure 2** Framework of the theory of change and the four mechanisms through which food policy actions could be expected to work. Reprinted from Hawkes C et al. *Lancet* 2015;385:2410-2421 (10). Copyright 2015, with permission from Elsevier. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

Benefit Transfer (EBT) card. The foods included reflect the nutritional needs of pregnant and lactating women, as well as infants and children to age 5. The food package has been revised significantly over time to reflect updated nutrition science and the Dietary Guidelines as well as more recent concerns about childhood obesity. Specific changes include adding fruits and vegetables, reducing the amount of juice provided, requiring whole-grain breads and cereals, and including only low-fat dairy (15). The WIC program disallows nutrient-poor, energy-dense foods such as soft drinks and most baked goods.

Recognizing the importance of breastfeeding to infant and child health (see previous paper, “Biologic Complications,” which implicates breastfeeding in self-regulation of appetitive behavior), the WIC program has also been updated to support this behavior. While infant formula is still available as an option for those mothers who choose it, exclusive breastfeeding is incentivized by providing a special “fully breastfeeding” package for mothers who do not receive formula. Mothers and infants may receive this package until the infant is 12 months of age. This package provides the largest quantity and variety of foods for the mother and also provides infant food meat and twice the amount of infant food fruits and vegetables as the WIC package that includes formula (16). This is an example of how a federal program provides a range of choices to participants while also incentivizing the healthiest behaviors (in this case, the behavior of fully breastfeeding).

Because the WIC program provides nutrition education and clinical care, there are opportunities to provide participants with the latest scientific evidence about dietary choices and health that relate to dietary self-regulation and appetite. For example, there is considerable research documenting children’s innate preference for very sweet drinks (17). In response, WIC families could be encouraged not to serve juice, or, if served sparingly, to dilute it with water (18). In another example, telling mothers about the recent and growing evidence that early introduction of peanuts can prevent future peanut allergies (19) could be incorporated into WIC education,

especially because peanut butter is a staple low-cost WIC food with high-quality fat recommended in the 2015 Dietary Guidelines.

While reformulating the WIC food package and restricting foods recommended by the Dietary Guidelines is justified from a nutritional perspective, there are concerns that this may be the reason behind a drop in program participation in recent years, particularly among mothers with children over a year old. This could be due in part to the notion of “reactance,” discussed later in this paper, in which restriction of certain types of foods may have the unintended consequence of making them more appealing. Offering more choice among approved foods is appealing to participants but also complicates program administration for retailers and program implementers. Striking the right balance between promoting the healthiest foods while also providing maximum choice is an active area of research. Food manufacturers can be part of the solution by reformulating their products to meet WIC requirements while maintaining appealing tastes and textures for young children.

Unlike WIC, the SNAP Program (formerly Food Stamps) has very few restrictions on the type of foods and drinks that can be purchased, other than alcohol and prepared meals intended to be eaten at the point of purchase. Originally designed as an income supplement program, there is vigorous debate in the nutrition and food insecurity communities as to whether some foods should be limited. The most frequently cited products for exclusion are sugar-sweetened beverages, due to the strength of the evidence that they are linked to negative health consequences (20).

To date, the USDA has not permitted any local city or state government to restrict food and beverage items that can be purchased with SNAP dollars; however, it is putting significant resources into nutrition education and increasingly toward policy, systems, and environmental (PSE) change to create healthier food choice environments. The Expanded Food and Nutrition Education Program provides nutrition education to low-income families who are likely participants in the SNAP program, including cooking demonstrations and

taste testing to help parents overcome food neophobia (fear of trying new foods) in their children and learn economical strategies for purchasing and preparing healthier foods. SNAP-Ed is a \$400 million program designed to nudge SNAP participants toward healthier choices. Historically, SNAP-Ed was used for nutrition education, but it can now be used to promote PSE changes. The USDA has recently funded a national research network to generate evidence about effective approaches to moving SNAP participants toward healthier food choices through both the Expanded Food and Nutrition Education Program and SNAP-Ed programs. Some examples of PSE change include healthy retail options, promoting school wellness policies, and encouraging taste preference development for fruits and vegetables through community gardens and cooking classes (21). The SNAP-Ed Toolkit helps program implementers identify evidence-based PSE and direct education programs to fit the needs of their communities (22). This shift toward a PSE approach to nutrition programming results from evidence that such broad population methods are ultimately more likely to have a larger and sustained impact than individual programs (23).

The combination of education and PSE promotion with the provision of food through the SNAP and WIC programs is a powerful combination in reaching those at highest risk for development of unhealthy nutrition patterns, consequent obesity, and related chronic diseases. The federal food programs need to remain flexible and capable of adapting nutrition messages and policies in response to new evidence related to appetite and self-regulation. For example, there are concerns about serving children artificially sweetened drinks based on emerging evidence that exposure to non-nutritive sweeteners may interfere with developing preferences for the flavors of healthy foods (see MacLean, Blundell, Manella, and Batterham, this issue). As this and other areas of dietary research grow, the federal programs must adapt to best meet the needs of the low-income Americans they serve.

## School policies

A patchwork of policies at the federal, state, and school district levels govern the school food environment in the United States (24-29). Historically, school meals have been governed by federal regulations (30) that guide the Child Nutrition Programs, which include the National School Lunch Program, School Breakfast Program, After School Snack Program, Summer Food Service Program, the Milk Program, and Child and Adult Care Feeding Programs. Prior the 2014-15 school year, state and district governments have primarily governed restrictions on the sale or provision of “competitive foods,” which are snack foods and/or beverages provided outside of meals through a la carte lines in the cafeteria, vending machines, stores, classroom parties and celebrations, rewards, and fundraisers (7,31-37). This changed in the 2014-15 school year, when competitive foods were moved into the federal government purview. Now all schools nationwide must follow the federal Smart Snacks regulations at a minimum.

The promising news is that school food policies at all levels of government are leading to meaningful changes in the school food environment and what is available for students to purchase and consume in schools. For example, one study compared dietary intake in students in California (a state with strong competitive food standards) to students in 14 states without any standards governing the sale of such foods. California high school students consumed on average

157 fewer calories in school per day than students in the comparison states (38), providing evidence that changes in the school food environment lead to a meaningful decrease in calorie consumption.

A challenge facing the field is that the implementation of effective school wellness policies is not universal (33,34,36,37,39-45). It is encouraging that strong (i.e., mandatory versus optional) standards that are consistent and comprehensive across grade levels are associated with reduced intake of unhealthy foods and sugary drinks, improved intake of fruits and vegetables, and lower rates of change in body mass index, obesity, and overweight status over time (37,39,41,43,46-48). On the other hand, policies that ban sugary drinks only at elementary and middle schools, but not high schools, or policies that ban only regular soda and not all sugary drinks, are less likely to have an impact on student behaviors and health outcomes (38,46,49).

Importantly, a few studies suggest that mandatory and consistent standards can have particular beneficial effects for low-socioeconomic-status students, for whom school meals often serve as a primary food source (38,45). For example, before the 2012 federal school meal standard revisions required a fruit or vegetable (FV) to be served with all school lunches, one study examined high school student FV intake in two states that already had this requirement as a state policy (i.e., California and Mississippi). The FV intake of the students in California and Mississippi was compared to FV intake among high school students in states without such a requirement. As expected, the findings documented that students in states with the FV requirement consumed more FV overall. However, this benefit was strongest among students who did not have regular home access to FV. In particular, students who had access to unhealthy snacks at home and did not have access to FV at home consumed 0.45 more cups per day of fruit and 0.61 more cups per day of vegetables than comparable students living in states without FV requirements (40).

This highlights how school policy can improve diet quality especially among students at highest risk of dietary deficiencies.

## Child care

Child care settings are another critical location for policy interventions designed to improve children’s diets, because most young children spend time in care outside of their homes (50). One of the earliest scientific efforts to improve the child care environment was the Nutrition and Physical Activity Self-Assessment for Child Care, developed by Ward and colleagues (51). The premise of this initiative was to guide child care centers through a process of self-evaluation of practices known to influence nutrition and physical activity, and then provide technical assistance to help them make improvements. There is strong literature supporting the effectiveness of this strategy (52,53). Research also suggests that children who participate in Head Start, which has very strong policies about health and nutrition, have a greater likelihood of entering kindergarten at a healthy weight than children who did not have the opportunity to attend Head Start (54).

Over the past half-dozen years, numerous national initiatives have emerged to engage child care centers to examine their policies and practices and update their approaches for promoting breastfeeding; limiting unhealthy foods and promoting fruits, vegetables, whole

grains, and low-fat dairy; limiting screen time; and encouraging physical activity, specifically outside. Excellent resources for individual child care centers or small child care chains are available from the CDC's website, *Addressing Childhood Obesity in the Early Care and Education Settings Opportunities for Action* (55), and from a comprehensive book that outlines recommended health and safety performance standards entitled *Caring for Our Children* (56). Beyond the individual center, another strategy to create improvements in the early care setting is to focus on state-level child care policies. Benjamin and colleagues have conducted quantitative scoring of the strength of state efforts to promote nutrition and physical activity in child care (57). This type of research is important to support national advocacy efforts to strengthen state laws regulating the environment in both child-care and after-school programs (58).

The federal food program most relevant to the child-care and out-of-school setting is the Child and Adult Care Food Program. Like the school meal programs, the Child and Adult Care Food Program was recently updated to align its nutrition standards with the Dietary Guidelines. The final rule, released in April 2016, contains a number of substantial nutrition components, including limiting juice to once a day, limiting added sugar in breakfast cereals and yogurt, prohibiting flavored milk for children aged 2 to 5, and encouraging that at least one of the two required components of a snack be a fruit or vegetable (59). As these new regulations are implemented across the country, research will be important to document the barriers, facilitators, and best practices for successful implementation of the new changes and to assess whether these improvements influence children's overall diets and can be used to encourage parents to serve similarly healthy meals and snacks to their children at home. Furthermore, evidence regarding early plasticity in flavor preferences (see the "Biologic Complications" paper) suggests that implementation of such federal level initiatives could be expected to impact overconsumption of sweet and salty foods, especially in children.

## Pricing strategies

Governments can attempt to decrease consumer purchases of unhealthy goods (e.g., sugary drinks, tobacco) and incentivize purchase of healthier products (e.g., fruits and vegetables) through fiscal policies (11). Evidence from the tobacco control field has consistently demonstrated that the most effective policy strategy for raising substantial revenues for governments and for reducing consumption of tobacco products is to raise prices through taxes (60-63). Importantly, the tobacco taxes that have been deemed most effective have been sizeable excise taxes (some on the order of several dollars per package of 20 cigarettes) (64). In the food arena, however, taxation is quite different. With one notable exception in the United States (Berkeley, California, as discussed below), the taxes applied to food and beverages are relatively trivial sales taxes added at the point of sale (generally ranging from 1% to 7% of the purchase price when a tax is applied) (65). These small taxes were never created to effectuate consumption changes; they were created to generate revenue and, not surprisingly, have generally been ineffective at changing consumption behaviors (66-71).

In an attempt to approximate how a large, excise-like tax-induced price increase might affect consumption, economists have examined the actual or simulated impact of prices on consumption and demand. Three of these studies found that consumption and demand for sugary drinks is generally price-elastic, meaning that demand is

sensitive to price changes (72-74). Yet, one simulation study estimated that sizeable excise taxes would have no effect on sugary drink consumption (75).

A practical empirical question regarding this pricing strategy is whether new excise taxes are passed onto consumers. The passage of the one cent per ounce excise tax on the distribution of sugar-sweetened beverages in Berkeley (effective March 2015) provided the first opportunity in the United States to explicitly study whether the tax was passed on to consumers through higher shelf prices. To date, two studies have examined this question.

One study examined pricing in Berkeley and pricing in San Francisco approximately two months prior to the effective date of the tax and compared these values to the prices approximately three months post tax implementation, and concluded that the tax was not passed through to consumers because the retail prices rose by less than half of the tax amount (76). However, another study conducted during a similar time frame but comparing prices in Berkeley with prices in both Oakland and San Francisco reached a different conclusion and found that at three months post tax implementation, retail prices of small (i.e.,  $\leq 33.8$  ounces) and larger (i.e., 2-liter bottles and multipacks) sugary drinks were significantly higher in Berkeley as compared to neighboring Oakland and San Francisco, California (77). For example, the price of soda in Berkeley as compared to the comparison communities increased by 0.69 cents per ounce following the excise tax (77). The different results in the two studies are likely attributable to methodological differences related to sample frames, comparison cities and products, and analytic methods.

The successful passage of a sugary drink tax in Berkeley appears to have been a turning point for the passage of taxes in the United States. In 2016, several local governments chose to introduce taxes, and Philadelphia, PA, Albany, CA, Oakland, CA, San Francisco, CA, Boulder, CO, and Cook County, IL all passed beverage taxes using municipal legislation and ballot initiatives. As each of these taxes are implemented, there will be opportunities for researchers to fully assess how prices change due to excise taxes in the beverage domain and, in turn, how consumer behavior is influenced.

In summary, there is currently mixed evidence on the impact of using price changes and taxes to positively influence food and beverage consumption; however, there are substantial reasons to continue to explore this strategy. First, unlike many environmental changes, this strategy would generate revenue instead of require more government or private spending. In fact, data from Berkeley indicates that during the first 9 months of the tax, over \$1 million was generated in new revenue for the city (78). This tax revenue was dedicated to increasing appropriations for the city (79); however, other jurisdictions could consider dedicating beverage tax funds for obesity prevention, nutrition education, and other public health programming (65,80). Second, a recent cost-effectiveness analysis of the potential impact of a nationwide \$0.01 excise tax/ounce over the 10-year period 2015–2025 found that it would avert 101,000 disability-adjusted life-years, gain 871,000 quality-adjusted life years, and result in \$23.6 billion in health care cost savings (81). Third, taxes have been identified as one of the most cost-effective strategies by saving more in health care costs than the cost to implement the tax (82). It will therefore be important to continue to monitor the implementation and impact of excise taxes across the

country to provide longitudinal data on the impact of sizeable taxes on revenue generation, unhealthy beverage consumption, dietary patterns, and associated health outcomes.

## Food marketing

One of the marked changes over the last few decades in the food environment is the tremendous growth in food marketing directed at children and adolescents. In the 1970s, Saturday morning cartoons with advertisements for children's presweetened cereals comprised the majority of child-targeted food marketing. In 2006, the Institute of Medicine released a report with a preface that began with the words "Marketing works" (83). The current generation of children sees an average of 4,700 ads a year on TV, while teenagers see 5,900 ads, reflecting the \$1.8 billion a year the food industry spends targeting young people. If these marketing strategies were promoting fruits, vegetables, low-fat dairy, and whole grains, one might argue that marketing can be part of creating a healthy environment. Unfortunately, that is not the case; the vast majority of ads children and teenagers see are for sugary breakfast cereals, fast food, sugary drinks, sweet and salty snacks, and candy (84-88).

For many years, the companies that marketed to youth claimed that they were not interested in increasing consumption of their category of product; they just wanted to increase their brand's market share. While this may have been true, an unintended consequence of the proliferation of marketing was that consumption within these categories increased as well (89). Experimental studies have found that when young children see products in packages with popular characters, they report that the products taste better (increased palatability) (90). Strikingly, when youth are exposed to either television commercials or playing branded advergames online, they eat significantly more snacks than when watching commercials for nonfood products or playing games that do not feature food (91,92). A recent review of the research on the impact of marketing on diet concluded that exposure to marketing has a significant impact on eating behavior and increases appetite and overall caloric consumption (93).

Changing the food marketing environment surrounding children and adolescents will require a range of policy changes that expand beyond television to other types of media. The sophistication and innovation of the food industry's efforts to reach youth improve each year. For example, in 2009, food companies spent \$122.5 million to target youth on "new media," including social media, food-company-sponsored websites, advertising on children's websites, and marketing via mobile devices (94). This represents over a 50% increase from 2006. The technology for reaching youth is changing faster than the research methods to track exposure, making this a critical area for further attention, including novel intervention strategies.

## Behavioral economics

Research in behavioral economics has illuminated how subtle environmental cues influence what and how much we eat. Individuals make more than 200 food-related decisions each day (95), making it difficult to devote real cognitive resources to any single decision. Instead, consumers fall back on rules of thumb or decision heuristics (96). By making use of the framing of decisions, the environmental cues that set social norms, and the choice heuristics individuals use to make food purchase and consumption decisions, it is possible to

design policies that are both effective and unobtrusive. The benefit of using the food choice environment to reframe food decisions is that cafeterias, grocery stores, restaurants, and other settings where people eat can be structured to influence choice without the individual experiencing the influence as coercive (97,98).

Much as food marketers are able to influence consumers to increase purchases, policymakers can use marketing strategies (e.g., product, placement, price, promotion) to help lead consumers to choose more nutrient-dense foods and to help them to limit their overall energy intake (99). Behavioral economics research also has a role to play in the private sector, where a growing body of work has demonstrated the potential for food retailers and manufacturers to use behavioral tools to help reduce overall consumption or increase selection of nutrient-dense foods while simultaneously having minimal (and possibly positive) impacts on profits. For example, Payne and colleagues (100) found that placards in shopping carts stating that average shoppers choose five or more produce items increases produce sales, while also maintaining overall sales. The perishable nature of produce means that the grocer achieves a relatively higher margin on produce than other items in the store; thus, this simple intervention benefits the grocer, increases the nutritional content of foods purchased, and leaves the shoppers' budget virtually unchanged. Foster and colleagues (101) found that increasing the number of visible cartons of lower-fat milk on the retail shelf leads to increased sales of lower-fat options without harming the selection of milk overall.

The potential for guiding consumer choices without raising opposition from either consumers or grocers is appealing. However, such tools have limitations and raise ethical questions (102). One perspective is to proceed cautiously because the exploration of such behavioral interventions is in its infancy, and we do not yet fully understand the extent to which these interventions can influence behavior. There are questions of the duration of the effects as well as whether environmental interventions in one setting can have spillover effects to other environments that have not been specifically engineered for healthier choices. Furthermore, some wonder at the ethics of influencing choice without a consumer potentially being aware of the intervention and argue that the fact that individuals may have incoherent or nutritionally suboptimal preferences does not necessarily mean that we can (or will) improve their wellbeing by intervening (102,103).

An alternative view is that retailers and manufacturers are already influencing consumers in ways that are detrimental to their health, and if it is ethical to use strategies to sell more unhealthy products, it is certainly ethical to use alternative strategies to sell fewer. The current retail environment did not emerge by random chance or accident.

Instead, it evolved in order to meet both the needs and impulses of consumers and maximize the profitability of the products being sold. Put simply, when a grocer decides to carry a new product, the decision is primarily a financial one—will it sell to their consumer base, and how much profit will it bring in? This motive is often in conflict with the consumer's wellbeing. The health impact of carrying a new product has historically not been part of the conversation or decision-making process. Therefore, an important area of research, policy, and advocacy is to find ways to include "health impact" in the decision-making process that creates the retail environment

available to consumers, especially consumers with limited financial and time resources available. This is the rationale behind policies such as strengthening the fruit and vegetable stocking requirements for stores that participate in SNAP or WIC. Once the healthier products are in the stores, other behavioral economic strategies (placement, lighting, promotion) can be used to encourage customers to select them. “Nudges” toward healthier food choices certainly seem ethical and have the potential to impact dietary composition.

## Changing defaults

One specific type of behavioral economic strategy is changing the default, which has often been discussed as a potentially fruitful intervention to change behavior (104). The power of defaults to influence choice was first illuminated by Johnson, who found that countries that have an opt-out policy for organ donation have substantially higher rates of organ donors than those with an opt-in policy (105). With respect to food decisions, many have hypothesized the potential for powerful changes by making low-calorie foods the default (e.g., apples instead of fries in children’s quick-service meals). In practice, however, such defaults face three challenges when influencing food consumption. First, defaults tend to work best when decisions are once-and-for-all, rather than repeated decisions such as what to have with lunch (106). Second, defaults fail when there is an excessively large disparity in the individual’s preferences between the possible options. For example, in one pilot study, Wansink and Just (107) offered third-graders a quick-service children’s meal with a choice of either French fries or apple slices. Children were randomly assigned to conditions where either the French fries were offered as a default, or apple slices were the default. Unfortunately, only a tiny percentage of those in the pilot study selected apple slices, even when they were the default. French fries were just too appealing relative to the apples. Slightly more promising results were found in a field experiment in which the healthier option was made the default and the children had not previously been offered an alternative (108). Children appeared to follow the default until they had gained enough experience to learn they could select the less healthy option. In this case, it can be beneficial to offer children some of each option. This strategy was employed when McDonald’s changed their default side with the Happy Meal from fries only to a combination of fries and apples. A Rudd Center study examining what parents and children chose at McDonald’s before and after this change found that the majority of customers did not change the default; therefore, the number of apples served in total increased and the number of fries served decreased after the default was changed. Thus, food choice was subtly guided to healthier consumption for children.

Some other defaults have been shown to work particularly well. For example, switching to chocolate milk instead of a soda default in children’s meals has had relatively powerful effects (109). Additionally, Just and Wansink (110) note that by changing the normative language around the size of dishes, they can have a substantial influence over selection and consumption. For example, consumers offered the opportunity to choose between two sizes of main dishes, side salads, and dessert, were drawn to select whichever size was labeled as “regular.” This was true even though the larger of the two options was exactly twice the size of the smaller, and participants could view and handle the sizes before selection. In a separate experiment, participants were given only one size option, but the description of the portion was randomized between “regular”,

“double,” or “half.” Those given portions labeled with a larger-sounding name consumed significantly less. Indeed, those who were told they were consuming a regular portion ate 140 calories more on average than those who were informed the same portion was a double. Similar sorts of reframing could be used to help make smaller or less-calorie-dense foods more normal.

Food consumers are also more likely to choose foods that appear to be more abundant. For example, Wilson and colleagues (111) conducted a pilot study in an upstate New York food pantry in which patrons, while making their way through the line, would be given a choice of either a bag of six donut holes or six bagels. While all available bagels were always visible on a table, the visibility of the donut holes was altered in some conditions to manipulate the perception of abundance. When donut holes appeared to be abundant, patrons chose the donut holes at a rate that was almost 400% higher than when they were not. Similar results have been found in both homes and restaurant settings (112).

Additionally, many have found that a menu must have a critical number of healthful options before consumers begin to see ordering such items as a normal action (113). These findings have implications for transmission of dietary patterns, as parents chose the food and create the eating environments for their children.

## Novel Approaches for Multidisciplinary Prevention and Intervention Strategies

In order to identify the most important policies to change, it is critical to develop a deeper understanding of how individual characteristics interact with the environment. For example, research suggesting that both artificially sweetened and sugar-sweetened beverages contribute to appetite stimulation can inform decisions about which products to allow in school or worksite vending machines. Knowledge about infant taste formation and subsequent taste preferences can support stronger hospital policies to promote breastfeeding and early child education policies regarding food offered to infants and toddlers. Understanding the psychological forces behind children’s trepidation in trying new foods (neophobia) can inform intervention strategies such as taste testing in the cafeteria and gardening at school, which expose children to foods multiple times, increasing familiarity. The following sections highlight opportunities for multidisciplinary prevention and intervention strategies.

### Infants and breastfeeding

There is evidence that a tremendous amount of brain development occurs during the first 1,000 days of life. The development of appetite regulation and flavor preferences occur during this time period as well, as is evidenced by research on the impact of flavor recognition among breastfed infants (17,114). Breastfeeding is also a very active policy target, with significant advocacy for the development of Baby-Friendly Hospitals and breastfeeding-friendly work policies (115). Research examining Baby-Friendly Hospitals and subsequent breastfeeding behaviors supports the assertion that babies born in hospitals with this designation are more likely to be breastfed exclusively and longer (116). Similar findings have emerged from studies on workplaces that support breastfeeding (117,118). A multidisciplinary approach to studying the impact of these policies could include



tracking dyads over time who were and were not exposed to these policies in order to identify psychological characteristics of the mother and infant that are associated with breastfeeding duration and subsequent infant reactions to new foods and flavors.

## Examine the interactions between psychology and environment

One strategy that has demonstrated substantial promise is that of a *behavioral interrupt*. This tool is rooted in the dual decision model (119), which supposes that individuals have two decision mechanisms. One mechanism is calculating and rational (considering price, health, etc), while the other is based more on reflex reactions (focusing on convenience or taste) (120). When cognitively taxed (121,122) choices are more likely to rely on habit, convenience, or environmental suggestions rather than deliberative processes. A behavioral interrupt can derail these reflexive decisions and lead to more thoughtful food decisions. For example, students asked to select their lunch options in the morning rather than while in the lunch line (when they are hungry and exposed to food smells and noise) decrease their selection of starchy sides by 25% (123) and increase their consumption of fruits and vegetables (124). Others find that simply asking a customer at a quick-service Chinese restaurant if they are willing to forgo a side dish to save calories (while paying the same amount) induces roughly one-third of customers to respond affirmatively (125). Such strategies to engage consumers in more thoughtful choices could be key to encouraging better choices without restricting choice or even circumventing choice through covert environmental cues. Developing these strategies will require a focused effort to determine the types of information, framing, or behavioral interrupts that are effective in breaking reflex consumption and stirring more cognitive engagement.

## Gaps in Knowledge

One of the challenges in studying the behavioral impact of policies is identifying the mechanisms through which they work for different people and testing for unintended consequences. The following section identifies some of the key challenges in this area.

### Need to understand compensatory behavior

One of the most important policy changes to improve children's nutrition in recent years was the USDA regulation of all foods and beverages sold in schools. Specifically, drinks with considerable added sugar have been removed from schools. One concern, however, is that regulating just one location in a child's food environment may not be enough to influence overall consumption. In this case, it is possible that children who attend schools that removed soda may compensate by drinking more soda outside of school, either at home or some other place. Similarly, students may switch from soda to another beverage that is still allowed, such as sports drinks or diet soda. Using the same example of school beverages, it is possible that the new policies may decrease what students consume while they are in high school; however, it is unknown whether this will have a long-term impact when they graduate and are no longer in the same environment.

The data on these questions is sparse and conflicting. Not only is more research needed on this topic, but it is going to be important

to go beyond average consumption among large groups of students in order to answer these questions. It is likely that some students are fairly easily influenced by the policy and do not seek out additional sources of soda, or switch to other sugary drinks, while others will put significant effort into obtaining the restricted product. The differences between these groups might be described as psychological or biological phenotypes—and a closer examination of who reacts how could reveal important factors that can either facilitate or inhibit the desired policy effects.

### Need to understand reactance

Reactance is a psychological phenomenon in which one rebels against a threat to freedom (126,127). Some argue that reactance increases the desirability of forbidden or discouraged objects (126). One of the first examples in the literature illustrating reactance involved signs on bathroom stalls discouraging graffiti (128). Signs that authoritatively ordered students not to engage in graffiti were met with a greater amount of graffiti, while signs that were more persuasive in their messaging were relatively more effective. Such reactance has been observed in the face of food restrictions. In studies of children, there is evidence that they will eat a greater amount of foods that have been restricted than other foods that have similar qualities (129,130). There is also evidence that individuals display positive emotional responses to the elimination of restrictions or enhancements to freedom (131).

Importantly, if reactance triggers excess consumption of the less healthy food, it can partially or fully undermine policies or regulations that conflict with consumer preferences. Marketing for unhealthy foods and messaging from groups that do not want to see the restrictive policy can stoke such conflicts. However, more subtle policies may avoid such reactance (132). For example, behavioral approaches that encourage or highlight more nutritious choices and discourage less nutritious choices, such as making white milk slightly easier to reach than chocolate milk, have been suggested for use in school lunch lines (133). Just and Wansink (134) were able to encourage greater consumption of carrots, for example, by giving summer campers a choice between carrots or celery rather than requiring them to take carrots. However, even a relatively restrictive policy has the potential to avoid reactance if framed in a positive and nonconfrontational way (135).

Just and Hanks (135) found, for example, that relative price incentives are more effective when framed as a subsidy on relatively healthier foods than when framed as a tax on less healthy foods—even when the overall prices paid are identical. Moreover, there may be some policy outcomes that can only be achieved with significant reactance, and policymakers will need to accept that there will be a period of adjustment. Many examples of this type of emotionally charged policy change can be found in the history of clean air regulation.

In the food area, one example of a policy that has had some pushback is the most recent change in the National School Lunch guidelines. One of the many changes in the guidelines required students to take one fruit or vegetable with their meal in order to qualify for the subsidy. Many have found that this requirement leads to an increase in the consumption of fruits and vegetables (106,136,137); however, due to the additional cost of providing additional servings of fruits and vegetables, there is disagreement on the cost-

effectiveness of the program. While no national study has yet been published, two studies conducted in lower-income, urban settings with concentrated population of minorities, (i.e., Boston, Massachusetts, and New Haven, Connecticut) found that consumption improved and fruit and vegetable waste remained the same or declined, suggesting that the policy led to the desired outcome (136,137). In contrast, studies in districts with a larger percentage of students who don't qualify for free or reduced price lunches (106), or a larger concentration of white students (138), have found relatively large increases in fruit and vegetable waste following the policy change.

There are a variety of potential explanations for these conflicting findings. School cafeterias vary considerably, and there are key characteristics that may influence how successfully the fruit and vegetable policy was implemented. First, the availability of competitive foods (snacks not part of the school meal) makes a difference in school meal participation in general (139) and may damage the potential of the fruit/vegetable policy if students purchase other snacks instead of eating the produce that came with their lunch.

Another factor is the quality and characteristics of the specific produce in question. There is a huge difference between fresh berries or melon versus old or overcooked vegetables. Recent focus group data with students from low-income districts suggest that students want to eat healthy foods—including fruits and vegetables—but they want the food to be high quality, specifically fresh, unbruised, served at the proper temperature, and prepared in a “homemade” fashion (140). If a food service manager does not believe the children will consume the produce, he or she may select less expensive, lower-quality products to save costs, inadvertently creating a self-fulfilling prophecy. Interestingly, low-income schools may be at an advantage because universal free lunch is associated with higher student participation, and higher student participation means there is more buying power and less risk involved in ordering more expensive, higher-quality produce. In order to fully understand the impact of this policy at the national level, large-scale studies are needed that use nationally representative samples and assess relevant state, district, and school-level variables.

## Need to understand how to effectively change social norms

Individual policies can change an environment and create optimal defaults that encourage the desired behavior; however, this is not the only way that policy can lead to change. When policies become commonplace, they also change social norms. For example, when clean air policies were first being introduced, they were highly controversial and difficult to pass. The natural course of events was that some progressive cities, counties, and states passed policies such as restricting smoking in government buildings and airports, and this grew to restrictions in restaurants, workplaces, and entertainment venues. Many years later, it is more surprising to find that smoking is permitted than restricted due to a reversal of the social norm.

In the food domain, several changes that have occurred may represent the beginning of a shift in social norms regarding eating behaviors. For example, cereal companies decreased the amount of added sugar in their child-targeted products (141,142); McDonald's changed default side from fries to apples and fries (143), and several restaurants have removed soda from their children's menus (142).

At what point will it be more surprising to find soda on the children's menu than it is now to find that it is missing? Perhaps there is a “tipping point” after which the social norm has changed and further efforts to improve the environment will take far less effort and resources. Research to better understand how social norms change, particularly as regards “healthy eating” and what factors push progress forward could help advocates plan for the future and allocate resources in the most effective way.

## Summary

Policies are the most distal influence on individual-level appetite regulation, yet these strategies can reach many people at once. To date, policy research has focused on the population as a whole, and in order to have significant impact, the effect of the policy change must be substantial. It is likely, however, that there will be individual differences in the degree to which people react in the desired way to the policy change. In order to further efforts to improve nutrition and health, it is important to understand how individual psychological and biological factors interact with the environment and policy influences. This will allow us to develop more sophisticated ways to create environments that will promote health for everyone. **O**

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