Journal of Applied Nutritional Sciences
An International Journal

Review Article

Review of Effect of Regulatory Strategies on Obesity

Sahar Zaghloul [1], Hebatuallah Awad[1], Nagwa Khallaf[2]

Authors Affiliation
[1] Department of Nutrition Requirements and Growth
National Nutrition Institute
Ministry of Health
Cairo Egypt
[2] Department of Field Studies,
National Nutrition Institute
Ministry of Health
Cairo Egypt

Correspondence to: Zaghloul S
zaghloulsahar@gmail.com

http://dx.doi.org/10.18576/jans/010301

Cite this as:
Zaghloul S, Awad H, Khallaf N. Review of Effect of Regulatory Strategies on Obesity. JANS 2022; Sep 1(3): - 63-91
Received: July 13, 2022
Accepted September 2, 2022

Abstract

Obesity increased dramatically over the last 25 years worldwide. Individual, community, and legislative interventions have been tested. This review examines the effectiveness of regulatory interventions. Method: Between 2005 and 2021, Medline, PubMed, and google scholar were searched for obesity, intervention, outcomes, strategies, healthy eating, and regulatory strategies. One hundred thirty-two papers and reports were identified, and 36 were selected for the current review to describe the outcomes of these strategies based on their effectiveness in reducing obesity rates. Results: Increasing taxes, regulating food marketing, and removing unhealthy food from food assistance programs helped reduce unhealthy food exposure, as did food labeling. Regulatory strategies have reduced consumption or purchase, but weight loss may take a long time to reduce weight. 20% volume-based tax of SSB reduced purchase and consumption with reasonable weight loss. Strategies to increase availability and access to healthy food to food program recipients or food producers showed a positive effect on consumption and weight loss. Price reduction of healthy food or its availability through food programs effectively increased consumption and reduced weight. Although not thoroughly tested, unhealthy food advertising is expected to work for children on the long term. Conclusion: Comprehensive strategies focused on reversing the obesogenic environment still require time to show their effect on weight reduction. However, increased availability and access to healthy food reduced exposure to unhealthy food and promoted physical activity has good potential to reduce obesity.

Keywords: Regulatory Strategies, Obesogenic Environment, Taxation, Subsidy Programs, Regulation of Food Marketing, Healthy Lifestyle

1. Introduction:

There is a growing number of people suffering from overweight and obesity all over the world. Obesity affects almost all age groups and both genders. According to the Global Disease Burden data, in 2015, there were 107.7 million

obese children and 603 million obese adults worldwide. Egypt had the highest rate of obesity among adults, where 35.3% of Egyptian adults were obese [1]. These growing numbers increase the burden and consequences on health and the economy. Obesity is 'the root cause of most non-communicable diseases" and increases the risk for hypertension, Type 2 diabetes, hyperlipidemia, and ischemic heart diseases. Therefore, it is urgent to find effective ways to stop this epidemic.

Since there is no single cause for obesity and because of its multifactorial nature, combined strategies to stop the obesity epidemic were suggested to be implemented at different levels. However, the leading cause of obesity is an energy imbalance, where calories consumed are higher than calories burnt. Although this might look simple to reverse this balance, it is a real challenge since many factors affect food choices and caloric intake. For many years, the focus was on nutrition education and information transfer to modify dietary behavior; however, recently, there has been an increased interest in changing the food environment through policies as a strategy to combat obesity and NCDs [2]. Environmental factors such as food availability, prices, and trade policies affect food choices and involve many sectors and stakeholders. Food industries affect food quality, amounts of fat, sodium, sugar, and additives and subsequently affect human health and eating behavior. In addition, individual factors like food preferences, eating habits, and traditions contribute to food selection and choices.

Different strategies were developed and tested. This includes strategies that aim to promote healthy eating by changing the food environment by increasing the availability of healthy food, control of food prices, limiting the production and marketing of unhealthy food, and strategies that aim to improve the lifestyle by encouraging both healthy eating and physical activity since unhealthy sedentary lifestyle is known to be a significant cause of obesity.

Healthy eating is a broad term that applies to many principles like eating enough calories, not less, and not more than an individual's need. According to most international dietary guidelines, healthy eating means consuming appropriate amounts of fruits, vegetables, and dairy products and reducing fat and carbohydrate consumption. Also, most of these guidelines recommend avoiding processed food, high sugar, and high salt intake. The World Health Organization (WHO) presented a regional framework for action on obesity prevention 2019 – 2023 [3]. The framework included commitment, strategic intervention, and progress indicators targeting regulatory actions, prevention, obesity management, and treatment and surveillance. Regulatory actions have set standards and laws for various sectors involved in the food supply system. Preventive actions aim to enhance physical activity through legislation, policies, and national and community-level interventions. Management and treatment strategies covered treatment options for obesity in health care services. Surveillance included evaluating obesity status in each country individually and monitoring the effect of all the strategies implemented by each country by measuring obesity rates to decide the appropriate strategy for each country.

The present paper aims to review the effect of regulatory strategies on weight control. However, it is worth noting that it is expected to take years to notice changes in obesity prevalence since time is needed for the development of action plans, implementation of strategies and evaluations.

Strategies addressing obesity management and treatment and strategies for obesity surveillance and prevention are beyond the scope of the current paper.

2. Methods

A computer search was performed using Medline, PubMed, and google scholar, searching for keywords: obesity, intervention, outcomes, strategies, healthy eating, and regulatory strategies between 2005 and 2021. The search yielded 132 papers and reports. Only 36 papers were selected for the current Review to describe the outcomes of these strategies according to the results of the studies that measured their effectiveness in reducing obesity rates as the final outcome or change in consumption as an intermediate outcome. Fiscal measures, public procurement, food supply and trade, labeling, and marketing were the five significant commitments addressing regulatory actions. Taxation of unhealthy food (sugar-sweetened beverages), subsidizing fruits and vegetables as an example of healthy food promotion, and elimination of subsidy from fat/oil and sugar represented suggested fiscal measures. Control of unhealthy food marketing and food labeling were examples of labeling and marketing of healthy foods. Public procurement actions included the provision of healthy food in public and institutions. Prevention strategies include adopting a healthy lifestyle of healthy eating and increasing physical activity.

3. Results

Many studies have been reviewed to address the effectiveness of regulatory measures and strategies for obesity. The overall goal of regulatory strategies can be summarized in actions to reduce unhealthy food, increase healthy foods and promote physical activity.

Regulatory Actions

Fiscal Measures

Progress indicators identified by the WHO to implement fiscal measures included the country's implementation of sugar-sweetened beverages taxes, additional levy additional taxes and /or subsidies to promote healthier foods, and elimination of all subsidies for oils/fats and sugar [3].

Impact of Taxes on Sugar-Sweetened Beverages (SSB) on Obesity

Sin taxes are the term that applies to taxes implemented on substance that proved harmful to human health and the most popular things with sin taxes are tobacco and alcohol. These taxes were applied in many countries as an apology and compensation from the users for the nation's health. The tax fund was directed to the health sector to promote and treat smokers. Many counties applied sin taxes on tobacco and alcohol, like Thailand, Philippines, South Africa,

England, and Australia, and reported success in reducing smoking prevalence. This encouraged policymakers and public health workers to consider a sin taxes policy to address obesity [4].

Sugar-sweetened beverages (SSB) are beverages with added sugar, and many products carry these criteria, like soda, nectars, sports drinks, and sweetened fruit juice. However, not all products contain the same amount of sugar, where sugar contents range from 10 grams per 12 ounces to 51 grams per 12 ounces [5].

With the growing market of sugar-sweetened beverages, the consumption of SSB between the years 1990-2015 increased by 5.2% among men and 9.2% among women [6]. This trend was apparently higher in Middle and Low Middle-income countries compared to high-income countries. It was found that three in every five adolescents consume SSB daily in Low- and Middle-income countries compared to two in every five adolescents in high-income countries [7].

Also, researchers proved the adverse effects of regular consumption of SSB on human health. Consumption of SSB was linked to obesity, dental caries, and non -communicable diseases in many studies [8]. Endorsed by the WHO in the commission on ending childhood obesity in 2016 [9], public health workers and policymakers were persuaded to target the reduction of SSB consumption. It was seen that SSB taxation would reduce the consumption of SSB and increase the consumption of other healthier options. It is believed that Low and Middle-income countries will benefit more from this policy than high-income countries [10].

Many countries have structured their taxes on volume base (i.e., 1 peso/liter), sugar-content-based taxes, or as ad valorem, value-based taxes (i.e., 10% of the manufacturer's price) [10]. The success of SSB taxation was summarized in Table 1, where success was measured by either reduction of purchase of SSB [11] or reduction in amount consumed [12,13] or reduction in mean weight [14-20], overweight and obesity prevalence [21-29]. However, almost in all reported research, the predicted weight reduction or reduction in the prevalence of overweight or obesity was based on estimation or prediction mathematical modeling in the long term extending from one year to 10 years. Moreover, taxes structured based on volume, sugar contents or value-based showed that volumetric taxation at 20% on SSB had the highest reduction in the prevalence of overweight and obesity. Only Fletcher et al. 2015 [30] showed no effect on body weight, and one study showed that weight loss with volumetric tax is more remarkable than with ad- Valorem tax [24].

Table 1: Summary of interventions targeting sugar sweetened beverages taxation

Author	Country	Intervention	Outcomes
Waterlander et al. 2014 [11]	Holland	13% ad- valorem tax (tax added on whole product)	Decreased family purchase of SSB by 0.9 liter per week Reduced personal caloric intake from SSB by 164 kcal per week.

Author	Country	Intervention	Outcomes
Colchero et al., 2016 [12]	Mexico	Applied 1 peso per liter tax (volumetric tax, tax per certain amount of product)	Reduction in consumption of SSB by 6% at the beginning of study and further reduction up to 12% was observed by the end of the study.
Falbe et al, 2016 [13]	Berkeley, USA	Excise tax one cent per one-ounce SSB	Decreased consumption by 21% in intervention cities Compared to increased consumption by 4% in other cities.
Etile et al,.2015 [14]	Australia	Simulation study to compare the effect of Volumetric tax 20% per liter SSB	Estimated those who consume 15 liters of SSB per month would lose 500 grams weight per months while those with higher consumption of 35 liters per months would lose 800 grams weight per month In ad- valorem tax no significant weight loss appeared.
Andreyeva et al., 2011 [15]	USA	One cent per ounce SSB	Linear estimation model predicts yearly weight loss by 2.2 kg body weight.
Zhen et al., 2014 [16]	USA	0.5 cent per ounce SSB	Dynamic model of 10 years of applying tax and its effect on body weight, reduction in body weight is the 0.7 kg in the low socioeconomic and 0.3 kg in high socioeconomic the 10th year of intervention
Ruff et al., 2015 [17]	USA	0.04 cent per calorie from SSB	Estimated weight loss of 0.7 kg in the first year and 0.3 kg in the tenth year
Long et al., 2015 [21]	USA	One cent per ounce SSB	The study estimates a decrease in obesity prevalence rate after 2 years of applying the tax by 0.9% in adults and 1.3% in adolescents
Kristensen et al., 2014 [22]	USA	One cent per ounce SSB	1.6% estimated decrease in obesity prevalence in children and 2.4% in adolescents
Gortmaker et al, 2015 [23]	USA	One cent per ounce SSB	Tax would result in reduction of obesity cases by almost 500,000 cases by 2025.
Sharma et al., 2014 [24]	Australia	Simulation study to compare the effect of Volumetric tax 20%	Weight loss with volumetric tax is greater than with ad- valorem tax

Author	Country	Intervention	Outcomes
		per liter SSB Versus ad valorem tax	
Lin et al., 2011 [18]	USA	0.5 cent per ounce SSB	Dynamic model of 5 years of applying tax and its effect on body weight, reduction in body weight is the highest in the first years estimated to be 0.9 kg it declined over years with total weight loss 1.8 kg in the 5 years of intervention.
Segovia et al., 2016 [19]	Ecuador	15 cent per liter	Weight reduction by 680 grams yearly
Basu et al. 2014 [25]	India	Ad- valorem tax 20%	Reduction in rates of obesity 3% among the whole population within 10 years of applying the tax.
Briggs et al., 2013 [27]	England	Ad- valorem tax 20%	Reduction in rates of obesity 1.3% among the whole population with greater reduction among those younger than 20-29 years (2.6%)
Bhimjiyani et al.,2016 [28]	England	Ad- valorem tax 20%	5% reduction in obesity rates by 2025.
Schwendicke et al. 2017 [29]	Germany	Ad- valorem tax 20%	Estimated reduction in prevalence of overweight and obesity by 3 and 4 % respectively. 20-29 years of age benefits the most with 22% reduction of obesity prevalence.
Fletcher et al. 2015 [30]	USA	Ad- valorem tax 12 %	No significant effect on body weight
Maneyma et al. 2014 [26]	South Africa	Ad- valorem tax 20%	Reduced obesity prevalence by 2.4 % among women and 3.8% among men
Dharmasena et al., 2012 [20]	USA	Ad- valorem tax 20%	Estimated reduction in body weight by 0.7 kg per year in average consumers and reduction by 1.15 kg body weight per year with higher consumption of SSB.

The Latin phrase ad valorem means "according to value.

A meta-analysis of nine studies examined the effect of the added taxes on the SSB demand using Price elasticity of SSB and cross elasticity. Price elasticity refers to the effect of increased price on demand and is considered negative when the price increase is accompanied by decreased demand and vice versa. At the same time, cross elasticity refers to the increased demand for other beverages with the decreased demand for SSB. This meta-analysis showed decreased demand for SSB with increased price indicating negative price elasticity. There was

an increased demand for other beverages like milk, artificially sweetened beverages, and fruit juice [31].

A systematic review of nine studies conducted in middle-income countries (Brazil, Ecuador, India, Mexico, Peru, and South Africa) studied the impact of SSB taxes on demand, and public health showed decreased demand for SSB with the increased price and that low – socioeconomic class showed a more significant decline in purchase and consumption [32].

A modeling study from Germany suggested that implementing a 20% tax on SSB will reduce consumption among young age and low-income populations; also, the mean BMI is expected to be reduced with the most significant reduction among the age group 20-29 years and more in males than females [29]. Another modeling study from Zambia predicted that a 25% tax on SSB price would result in an annual revenue increase of 5.46 million-dollar, a reduction in the prevalence of obesity among both men and women. However, women will benefit more because of their higher baseline BMI and estimated that 2526 annual deaths from NCD would be averted [33].

In 2014, Mexico implemented a tax on SSB (11%), which reduced monthly purchasing by 6% in six months, followed by12% by the end of the year. Low socioeconomic participants had the highest reduction in purchasing. No data are available regarding the impact of the tax on health and body weight [34].

England reduced sugar consumption by implementing a soft drink industry levy in 2016. It announced that a sin tax would be applied on soft drinks that contain more than 5 grams of sugar per 100 ml as an intervention to reduce the rates of childhood obesity in England, where sugar consumption was three times the recommended daily allowance among children. In 2018, the volume of sugar purchased per capita declined by 30%, with estimated daily reduced consumption of 4.6 grams. However, sales of soft drinks remained the same as manufacturers were incentivized to produce drinks with a sugar content of fewer than 5 grams per 100 ml, and the sales of these products and zero sugar products had increased [35-37].

Experiences from the Middle Eastern countries were described in a study conducted by the WHO to examine the effect of sin taxes on SSB, applied by the Gulf Cooperation Council countries, on the growth rates and sales volume of SSB from 2010 to 2020 [38]. Results revealed that from the year 2016 to 2017, when the Kingdom of Saudi Arabia, United Arab Emirates, and Bahrain implemented a tax on SSB, the growth rate of sales volumes decreased in Saudi Arabia from 5.44% to 1.33%, from 7.9% to 5.9% in the United Arab Emirates and modest decrease from 5.2% to 5.09% was recorded in Bahrain. Qatar and Oman were the next to implement sin taxes to SSB in 2019, followed by Kuwait in 2020, and they also showed a reduction in the volume of the growth rate of sales of soft drinks. However, none of them had data regarding the impact of the tax on obesity rates and still followed the modeling method in expecting the outcomes on health and obesity [38].

Careful evaluation of the impact of this policy is warranted since the implementation of sin taxes would have social and economic implications raising inequity between the rich and the poor by affecting the industry and labor force. The other concern is the need to have obesity assessment surveys or surveillance rather than rely on modeling and simulation studies.

Impact of Elimination of Subsidies on Fat and Sugar and/or Subsidizing Fruits and Vegetables

Food subsidy is another critical economic factor affecting food purchasing and consumption. Worldwide, policymakers considered food subsidies for healthy food to reduce obesity. Grains like raw wheat or bread, rice, and corn are the most common subsidy food offered. Also, sugar and plant oils are subsidized in many low-income countries to ensure providing vulnerable groups with enough energy with the long-term effect of gaining extra weight and subsequently increasing non-communicable diseases due to taking more calories than recommended [39-41].

In addition, the increased rates of micronutrient deficiencies or "The Hidden Hunger" indicate the failure of the current subsidy policies, and reconstruction of these policies is needed [40].

Fat and sugar taxing and fruits and vegetable subsidies were studied in a simulation study conducted in New Zealand. Taxes on sugar, saturated fats, and salt were set, 8% tax on junk food and a 20% subsidy on fruits and vegetables were considered. The modeling study outcomes were a) changes in purchasing unhealthy taxed items, b) changes in fruits and vegetable consumption, and c) health outcomes. This study estimated an increased purchase of fruit by 16%, vegetables by 32%, and reduced the purchase of fats by 10%, sugar and sugar-based food and beverages by 33%, and 12% for salt. Health gains were estimated in the form of health-adjusted life span and health care costs. Life span was estimated to increase and reduce the costs of treating non-communicable diseases related to food [42,43].

Early 2004, a study investigated the possible effects of fruit and vegetable subsidies (also called thin subsidies) on body weight reduction. It concluded that reducing the prices of fruits and vegetables at retail will increase their purchase and consumption with positive health outcomes and serve the low-income population [44].

Table 2 summarizes studies conducted to examine the effect of subsidizing fruits and vegetables on purchasing and/ or the intake of fruits and vegetables as primary outcomes that can predict changes in body weight and obesity prevalence as secondary outcomes. It is clear that subsidizing healthy foods such as fruit and vegetables promotes healthy eating behavior [45-48] and subsequently contributes to weight reduction [46]. More critical the behavior modification was sustainable [47,48]. Nutrition education is an essential component of any intervention to strengthen its impact; however, nutrition education alone failed to make noticeable changes [11].

Table 2: Summary of interventions targeting subsidy programs restructures

Author	Country	Interventions	Main outcomes
Burr et al. 2007 [45]	UK	Setting: Antenatal care clinic Sample and design: 190 pregnant women were randomly allocated to three groups: a control group (received usual care); an advice group (given advice and leaflets promoting fruit and fruit juice consumption); a voucher group (given vouchers exchangeable for fruit juice) Measurements: Dietary questionnaires were administered at 16, 20 and 32 weeks of pregnancy. Serum b-carotene was measured at 16 and 32 weeks as a biomarker for compliance to fruit and vegetables consumption.	Serum β-carotene declined during pregnancy in all groups, but fruit juice consumption increased substantially in the voucher group. Serum β-carotene concentration increased in the voucher group, from 106.2 to 141.8 µmol l− (P=0.003). In control group: serum β-carotene decreased from 120.0 to 99.8 µmol l−(P=0.005) and was unchanged in the advice group.
Kennedy et al, 2009 [46]	USA	Two-arm intervention study among African American women. Intervention included 1.Free fruit and vegetables $10/week with recipes from mobile store at community center 2. Monthly nutrition/ cooking sessions. Measurement: anthropometric assessment	The intervention group lost a mean weight of 2.0 kg, while participants in the control group gained a mean weight of 1.1 kg at six months. Overall participants showed a mean decrease in weight of -.4 kg (standard deviation 3.0 kg), but the intervention group lost significantly more weight and had a decreased body mass index at six months. In the intervention group, the average number of servings consumed per day of fruits/ fruit juice and vegetables significantly increased at six months.

Author	Country	Interventions	Main outcomes
Herman et al., 2008 [48]	USA	WIC Women who enrolled for postpartum services. Intervention: Standard WIC program plus $10 voucher weekly for F and V from local supermarket (SM) or farmers market (FM) Duration: Vouchers for 6 months. Measurements: Dietary data were collected at baseline during intervention and 6 month after.	Intervention participants increased their consumption of fruits and vegetables and sustained the increase 6 months after the intervention was terminated.
Waterlander et al., 2013 [11]	Denmark	6 months RCT within Dutch supermarkets was conducted. Regular supermarket shoppers were randomly assigned to 1 of 4 conditions: 50% price discounts on fruits and vegetables, nutrition education, 50% price discounts plus nutrition education, or no intervention. Dietary data were collected. Duration 6 month	The percentage of participants who consumed recommended amounts of fruits and Vegetables (≥400 g/d) increased from 42.5% at baseline to 61.3% at 6 months in both discount groups (P = 0.03). Education alone had no significant effect.
Bihan et al., 2013 [47]	France	12-month randomized controlled trial, 302 low-income adults 18–60 years old dietary randomized to advice alone ('advice'), or dietary advice plus FV vouchers ('FV vouchers') (10–40 euros/month) exchangeable for fresh fruits and vegetables	Between baseline and 3-month follow-up, frequency of FV consumption increased significantly in both the advice and vouchers group. However, the vouchers group consumed more servings of fruits and vegetables and the percentage of low fruit and vegetable consumers were significantly less among the vouchers group.

Food Marketing Regulations

The main food marketing strategies studied were food advertisement, sale point promotion, and food prices. Strategies to reduce children's exposure to unhealthy foods and food prices strategies to make healthy food more available and accessible showed mixed results.

Food advertising through media channels like television, radio, and the internet, especially when high advertising fat, high sugar, and low nutritive value food, has been proven to adversely affect dietary habits and food choices among children and adolescents [49]. A meta-analysis of 29 studies examined the impact of exposure to food ads of high fat, high sugar food items on children and adolescents between 2-18 years of age. Exposure to these ads leads to increased consumption of these food items, altered dietary habits of children and adolescents, increased body weight, and increased rates of overweight and obesity [49].

For ages, television has been the main channel to target children for food advertisements. However, now children spend long hours playing online games, browsing different social media platforms and online video channels rather than watching television; therefore, advertising agencies are targeting children through these channels. A randomized cross-over study was conducted to compare the effect of television food ads versus television and internet food ads on food consumption among children between 7-12 years old. It was found that children tend to consume more food immediately after watching food ads on television or the internet. However, children tend to eat more after watching ads on television and the internet rather than watching ads on television only [50].

In 2015 a study was conducted in Oman to study the types of food items advertised to children through television, radio, and print media ads between November 2015 and January 2016, with a total of 306 broadcast hours, 140 hours of television, and 168 hours of radio. Most television ads were about to follow up the formula, sugar-sweetened beverages, and snacks like cakes, biscuits, and chocolates. Only 3% of these ads were about cheese and 7% about ready-made meals and composite dishes. Radio ads, however, were mainly savory snacks and some frozen food like meat, poultry, and fish, with few ads about pasta and fats like butter and oils. Also, few printed media were found compared to television and radio that promote high-sugar snacks. The study included ads on three media channels, unfortunately not including the internet or the most watched media channel for children where the massive advertisement of food is running through social media and online games. Similarly, the study did not include sale points and school and social events, where food marketing is common. However, this study concluded that limiting food ads of high calorie, low nutritional value food items is one of the most essential recommended strategies to control the increasing number of overweight and obese children [51].

A review paper summarized governmental regulations set by 16 countries to limit the marketing of unhealthy food to children, including developed and developing countries [52]. These studies included regulations set by developed countries like England, Ireland, and South- Korea and developing countries like

Mexico, Chili, Spain, Turkey, Taiwan, and other countries. The cutoff age targeted to be protected from food advertisement differed by countries such as less than 18 years old, less than 15 years old, and less than 12 years old. Unfortunately, the outcome of these regulations measured by changes in children's body mass index or dietary habits were not reported. However, Tallie and coauthors [53] studied the impact of Chile's law of food labeling and advertisement implemented in 2016 and revealed decreased purchases of high sugar beverages by 22.8 ml/capita/day ($p<0.001$) and calories by 11.9 calories/capita/day (95%CI -12to-11.9; $p< 0.001$). Similarly in the UK and Canada, households with children spent less per capita/quarter on food high in fat, sugar and salt and more on fruits and vegetables [54, 55]. Most manufacturers use special offers and reductions in the price of unhealthy food as a marketing strategy which unfortunately work [53].

Food price affects people's choice of food, so lowering the price of healthy food encourage purchase. A study conducted in New Zealand among 1104 shoppers evaluated the effect of price reduction on purchasing healthy food items like fruits and vegetables. Purchase of these items increased by 11% for six months even after the discount is over and by 5% for 12 months even after the discount is finished [42]. Another study compared the effect of nutrition education versus price reduction on purchasing healthy food items and found that nutrition education was not enough to increase the purchase of healthy food [43].

It is important to note that marketing regulations to help reduce obesity should not harm producers. There should be an agreement with food manufacturers to produce and market healthy options as the example from South Korea where producers reduced calories by decreasing sugar, trans fat and fat [56]. Suggested solutions to improve food marketing and promote health included eating half portion with a 70% reduction in the original price at restaurants and giving fruit-free coupons for children at supermarket [57] (Table 3).

Table 3: Summary of interventions targeting healthy food marketing

Author	Country	Interventions	Main outcomes
Taillie et al., 2020 [53]	Chile	Chile's Law of Food Labeling and Advertising implemented in 2016, that restrict child-directed marketing, and ban sales in schools of all foods and beverages containing added sugars, sodium, or saturated fats that exceed set nutrient or calorie thresholds	Purchases of high sugar beverages decreased by 22.8 ml/capita/day p<0.001 Calories from high sugar beverage purchases decreased by 11.9 calories/capita/day (95%CI -12to-11.9; p< 0.001)
Silva et al., 2015 [54]	United Kingdom	United Kingdom Code Of Advertising broadcast BCAP is divided into 3 stages	The study measured the effect of implementing the code of advertising on household

Author	Country	Interventions	Main outcomes
		Before 2004 there was no regulations for unhealthy food advertisement in UK Between 2005 -2007 companies started voluntary changes to the nature and budget of food ads called self- regulatory phase. In 2008, the British Code of marketing was published, in addition to self –regulations this is called co-regulations.	expenditure on food high in fat, sugar and salt (HFSS). Under both self-regulation and co-regulation, households with children spent less per capita/quarter on HFSS foods and HFSS drinks and more on fruits and vegetables ($P < 0.01$ for all). Households without children were less affected by co regulation.
Kim et al., 2013 [56]	South Korea	Special Act on Safety Management of Children's Dietary Life Safety Management was implemented September 2010	Energy Dense Nutrient Poor companies (EDNP) reported reducing energy by lowering free sugar content ($P <0.031$), reducing fat and trans fatty acid content ($P < 0.023$; $P < 0.018$, respectively). A significantly greater percentage of EDNP companies fortified their products with vitamins or minerals ($P < 0.014$) or with protein ($P <0.022$).
Dhar and Baylis, 2011 [55]	Quebec, Canada	Consumer Protection Act, implemented 1980, updated guidance issued 2012	The current study provides evidence that a ban on advertising targeting children can be effective in lowering or moderating consumption and estimates of the effect in expenditures suggest that the social-welfare impact of such a ban can be significant.
Taillie et al. 2019 [52]	Different countries	Review of literature on different regulatory measure developed by various countries to stop childhood obesity by limiting exposure of children to food advertisement especially high sugar high fat food	First of all every country have its own specified age group who they consider vulnerable and should be protected. Various policies and regulations were developed no single strategy for all.

Author	Country	Interventions	Main outcomes
			Finally, most of the studies focused on the exposure to ads as outcome and little or limited studies measured the effect of regulations on consumption of HFSS on children's BMI. Therefore, it is recommended to study the effect of purchase and consumption on BMI in future studies.

Food Labeling

Food labeling supports informed choice where labels are applied to food packages to give the customers essential information about the nutrition facts of their food choices and the amount of nutrients that might harm their health per each package. Sugar, sodium, trans fats, and saturated fats are the main target of food labeling; based on scientific research consuming large amounts of these nutrients increases the risk of chronic diseases like obesity, diabetes, and heart diseases.

Food manufacturers have used front-of-package food labels as a marketing tool where they highlight the advantages of their products using claims like Natural products, Halal, No added sugar. Different countries have adopted food labeling policies; each country uses a different form of front of the package label.

Types of Front of Package (FOP) Food Labels

Claims: a simple piece of information delivered to the customer regarding the product using terms like reduced, low, free, etc. Claims are classified into health-related ingredient claims, nutrient content claims, comparative nutrient claims, general health claims, nutrient, and other function claims, reduction of disease risk claims, and other claims like organic or Halal [58].

Nutrient-specific labels: where the amount of specific nutrients is mentioned compared to the recommended daily value, there are two types of Nutrient specific labels the Guideline Daily Amounts (GDA) and the Color Coded Guideline Daily Amount (Color-coded GDA), where the red color indicates" High amount," yellow indicated "Medium amount," and green indicated "Small amount" [59]. Traffic light food labels: these simple color-coded Front of Package food labels were used primarily in the packages of food consumed mainly by children and teenagers, with the same color code as the color-coded GDA [59].

Warning labels: A simple warning sign with a simple informative sentence, like high in sugar [59].

Summary Indicator Systems: The product carries an association or organization logo that supports using this product, like The American Heart Association Red Tick [59].

In Latin America, three countries applied mandatory food labeling (Mexico, Chile, and Ecuador), and others had voluntary food labeling systems. Studies examining these policies' effects on food choices and obesity are scarce. Also, studies mainly examine purchasing and consumption behavior as primary outcomes, and changes in body weight and the prevalence of obesity are mainly discussed in modeling studies based on the changed consumption behavior [58].

Using Chile national data on household food purchases from before and after policy implementation, changes in purchases of beverages high in sugar, saturated fat, sodium, or calories (i.e., "high-in" beverages) were examined. The results showed that purchase volume of high-sugar beverages decreased by 22.8 mL per capita per day or 23.7% [53]. Modeling study to examine effect of food labeling policy on obesity rates. Baseline intakes of beverages and snacks were obtained from the 2016 Mexican National Health and Nutrition Survey [60]. The expected impact of labels on caloric intake was obtained from an experimental study, with a 10.5% caloric reduction for beverages and 3.0% caloric reduction for snacks (Table 4).

Table 4: Summary of interventions to assess effect of food labeling

Food labeling policies to reduce obesity.		
Taille et al., 2020 [53] Chile	Observational study to evaluate the purchasing of high in sugar , sodium and saturated fat beverages after applying phase 1 of the Chilean law of food labeling, in the period from 2015 to 2017.	Using national data on household food purchases from before and after policy implementation, changes in purchases of beverages high in sugar, saturated fat, sodium, or calories (i.e., "high-in" beverages) were examined. The results showed that purchase volume of high-sugar beverages decreased by 22.8 mL per capita per day or 23.7%. Both high-educated and low-educated households had similar absolute reductions in high-sugar beverage purchases. However high-educated households had larger relative reductions in high-sugar beverage purchases.

Food labeling policies to reduce obesity.			
Basto-Abreu et al., 2016 [60]	Mexico	Modeling study to examine effect of food labeling policy on obesity rates. Baseline intakes of beverages and snacks were obtained from the 2016 Mexican National Health and Nutrition Survey. The expected impact of labels on caloric intake was obtained from an experimental study, with a 10.5% caloric reduction for beverages and 3.0% caloric reduction for snacks.	The expected outcome is a reduction in prevalence of obesity by 1.3 million cases five years after implementation of FOP food labeling policy.

Public Procurement and Integral Approaches to Reverse Obesogenic Environment: *School Interventions to Encourage a Healthy Lifestyle in Schools*

A sedentary lifestyle and unhealthy eating lead to energy imbalance and increased body weight and body mass index. It reflects an individual choice to lead a healthy or unhealthy lifestyle. Much research considered obesity an individual choice aggravated by individual decision to lead an unhealthy lifestyle neglecting the effect of the surrounding environment. However, some researchers accused the fast food chains, food marketing, and the hectic lifestyle as additional factors that adversely affect individual's choice. Recently researchers had a broader view and studied the impact of different environmental factors on the individual's lifestyle and food choice and on weight and health. Some of these studies explored the access to recreational activities, transportation, access to healthy food, neighborhood safety as causes of obesity. The term "Obesogenic Environment" started to be recognized when in 1999, Swinburn et al. [61] published a paper describing a framework for understanding obesogenic environment and developed the Analysis Grid for Environments, a practical tool for prioritizing environmental elements linked to obesity. The obesogenic environment was described as "the sum of influences that the surroundings opportunities or conditions of life have on promoting obesity in individuals or populations [61]. The factors inside and outside the home that alter the child's eating behavior and physical activity led to increase his/her body mass index [62]. Lately, Kaczynski and his colleagues [63] defined the obesogenic environment as the sum of physical elements within communities that promote a sedentary lifestyle, restrict physical activity, encourage unhealthy eating practices among children, and developed a childhood obesogenic environment index (COEI). After the principle of the Obesogenic Environment has been acknowledged, reversing the obesogenic environment becomes a priority to stop the obesity epidemic, especially among children. Small communities like schools, daycare facilities, after-school, and worksites were considered well controlled research sites. Besides it allows easy

access to large sample of children at different developmental stages (age between 6-18 years) and where promotion of physical activity could be easily implemented In addition, school obesity interventions were prioritized by many countries since children and adolescents represent the future adults and preventing childhood obesity would have impact on the future of global health [64].

Environmental strategies are the hardest to implement as they require interdisciplinary collaboration of different stakeholder from the health and non-health sectors. Studies evaluating the effect of integral approaches to reverse school obesogenic environment were thought to be highly promising to promote healthy lifestyle and prevent obesity. The main components of strategies that target the reduction of childhood obesity in schools included

- *Improvement of the food environment to promote healthy eating through school meal programs,*
- *Proper control of the food sold at the school canteen and school surrounding area, and*
- *Promotion of healthy choices through incentives and encouraging students to make healthy choices.*

In addition, an essential component included promoting physical activity at school and raising the awareness of a healthy lifestyle through activities and classes [65-67].

School interventions were reviewed and included 43 meta-analyses, 63 systemic reviews, and 11 other reviews covering primary and secondary schools, with few studies on the preschool establishment. Key findings from research conducted in high-income countries showed success in the weight reduction of children from < -0.1 kg/m2 to -1.8 kg/m2 when a multi-component program was designed combining diet and physical activity interventions [68-71]. Many studies showed dietary behavior modification, such as increasing fruit and vegetable consumption [72-75] and decreasing sugar-sweetened beverages consumption [76].

Interventions Addressing Increasing Access to Healthy Food

Interventions aimed to improve diet through changes in foods provided by the school canteen/cafeteria, increased physical activity during or after school hours combined with education for healthier dietary and activity behaviors, and parental involvement reduced BMI by -0.072, systolic blood pressure by -0.183 and diastolic blood pressure by -0.071[76]. Oosterhoff et al. [77] reported reduced anemia prevalence in adolescents, especially girls, when micronutrient supplementation intervention was implemented (RR:0.69, 95% CI: 0.62-0.76).

School-based interventions to promote fruits and vegetables consumption were in the form of classroom and non-classroom education (integration of knowledge about the importance of fruits and vegetables in the curriculum), changes to the environment (such as increased fruits and vegetable exposure in the canteen, modifying lunches, breakfast or snacks provided [78]. A USDA report published in 2012 showed that combined interventions showed better results [79].

Combined interventions targeted nutrition education and school food environment through free breakfast, increased availability of healthy food in school cafeteria/vending machines, free fruit and vegetable snacks, increased fruit and vegetable choices marketed, and improved preparation and appearance led to more remarkable improvement than each intervention separately [79].

Pre-school (2-5 years) interventions to increase vegetable consumption included educational interventions, repeated taste exposure, pairing, changed food –services, explicit rewards, modeling, variety, and visual presentation [80].

Similarly, intervention strategies included laws and policies to increase access to healthy food (free or subsidized) and reduce unhealthy food or beverage availability, awareness and education, family and community involvement, nutrition in the school curriculum, interactive information and communication technologies, school teaching kitchens, school garden, counseling of school health nurses [79,81].

Interventions implementing curriculum, environment, and families/communities to promote the diet and physical activity showed inconsistent results with no significant effect on BMI [82]. However, interventions targeted overweight and obese children that include physical activity reduced BMI by -0.35 kg/m2 when delivered to obese and overweight children than to all children [83].

Strategies used in nutrition education interventions included information sessions or lessons, practical hands-on skill building, teacher training, PA, and school cafeteria modifications [84,85]. Also, educational games simulating food purchases according to menu labeling with numeric calories and nutrient contents [86, 96] and computer and internet-based activities were tested [79]. Moreover, literature revealed that nutrition education interventions longer than one year were effective in reducing BMI [87], and the most prominent effects seen were in programs with parental support [88, 95].

Regulations, standards, and guidelines to increase the availability of healthy and decrease the availability of unhealthy foods and beverages, shown in Table 5, have positive changes in healthy food purchasing patterns, the intake of healthy foods, and decreasing the intake of foods high in fat, sodium, and sugar [89, 92, 95, 96].

Table 5: Summary of studies to test school interventions to promote healthy lifestyle

Author	Country	Intervention	Outcomes
Ickovics, et al., 2019 [93]	Singapore	Randomized cluster trial of 12 schools support was provided for implementation of nutrition policies (e.g., alternatives to food-based rewards/celebrations) and physical activity policies (e.g.,	Students at schools randomized to receive support for nutrition policy implementation had healthier BMI trajectories over time (F=3.20, p=0.02), with a greater magnitude over time

Author	Country	Intervention	Outcomes
		opportunities for physical activity during/after school).	and cumulatively significant effects 3 years post-intervention There was no difference in student BMI between those in schools with and without physical activity policy implementation.
Miyawaki et al., 2019 [92]	Japan	Implementing school lunch program that offers uniform meal including staple food, main dish, side dish, drink and dessert for elementary school students and Junior high school students and follow up for 3 years.	A 10 percentage point increase in the coverage-level school lunch coverage rate significantly decreased the percentage of overweight (0.37%, 95% CI: 0.18–0.56) and obesity (0.23%, 0.10–0.37) in subsequent years among boys, but not among girls. No significant effect on the percentage of underweight or mean body weight/height was observed for either sex
Matsuzaki et al., 2021 [95]	USA	Implementation of California and Federal Nutrition policies among school children California nutrition policy limits the availability of beverages in elementary and middle schools. In 2007, CA introduced statewide nutrition and portion size standards for competitive foods in grades K-12. The policies set the maximum number of calories in snacks or entrees and percent of calories from fat at 35% and from saturated fat to 10% and sugar content to no more than 35% by weight. The federal policy— *HHFKA 2010 set caloric limits, and increased daily availability of	The results generally showed favorable association of the California nutrition policies with overweight/obesity prevalence trends, although the magnitudes of associations and strengths of evidence varied among racial/ethnic subgroups

Author	Country	Intervention	Outcomes
		fruits, vegetables, and whole grain–rich foods, limited fat content of milk and portion sizes, and reduced levels of sodium, saturated fat, and trans-fat	
Habib-Mourad et al., 2020 [96]	Lebanon	Implemented Ajyal Salima program which is a school obesity prevention program with 3 components The first component is a session of interactive nutrition education delivered to students The second is a nutrition education session for parents together with delivering education material to take home and serving them a healthy meal The third component is about school meals and limiting high fat high sugar food availability in school canteen.	The odds of being overweight/obese post intervention were similar in intervention and control groups. After one-year washout, changes were observed only in public schools. Students in the intervention group had a 52% reduced odds of being overweight/obese compared to students in control group. Dietary habits changes included increased consumption of fruits and raw vegetables and decreased consumption of chips and deserts. However after one year washout period these changes didn't last.

*Healthy, Hunger-Free Kids Act of 2010

Interventions to change the environment, such as restriction of sugary foods and beverages or high-fat foods and increased availability of water, milk, and fruits and vegetables, resulted in improved purchasing or self-reported diet [90].

Additionally, simple interventions such as improving the placement of water and healthier beverages (milk), improvement in the preparation and appearance of food, use of emoticons, and rewards for selecting healthier options effectively reduced sugar-sweetened beverages (SSB) intake [91,92]. Students had healthier BMI trajectories overtime and cumulatively significant effects three years post-intervention [93].

Other reported interventions where a school wellness council was established and a written school policy about a healthy school environment was developed effectively promoted a healthy lifestyle among children [93, 94]. Last but not least, interventions to promote physical activity like reconstruction of the playground to be more active, all class participation in physical education classes,

change in recess time activities to be more physical, giving incentives to children to participate in sports, social marketing of healthy lifestyles in the form of slogans and stickers, inviting stakeholders and community service providers in fundraising events to support healthy school environment were found successful [95].

4. Discussion

Obesity is a multifactorial health issue threatening the world with its increasing numbers among different age groups. Regulatory actions have shown a reduction in consumption or purchase; however, little impact on weight reduction has been reported, which may require more time to show the impact on weight. The key is reducing the obesogenic environment by reducing exposure to unhealthy food, increasing the availability of healthy food, and promoting physical activity. Unhealthy food exposure through increased taxation, regulation of food marketing, elimination of unhealthy food from food assistant programs (school feeding programs), and educational strategies through food labeling have shown purchase and consumption reduction. Also, among different taxation strategies, the increased volume-based taxation of SSB at 20% reduced the purchase and consumption of SSB with reasonable weight reduction. Considering dietary changes as intermediate outcomes, more research is needed to assess weight loss or halt through anthropometric measurements.

On the other hand, strategies to increase availability and access to healthy food through incentives offered at the individual level in food programs or food producers to produce more healthy products reported more effects on both consumption and weight reduction. Also, healthy food price reduction or its availability through food programs has been proven to be an effective strategy to increase healthy food consumption and, subsequently, weight reduction. Unhealthy food advertisement, although not fully tested, is expected to work with children long-term to create a non-obesogenic environment. Little research evaluating the effect of food labeling limited the ability to conclude.

5. Conclusion

Comprehensive strategies with combined interventions to reverse the obesogenic environment with two main goals 1) increase availability and access to healthy food and 2) reduce exposure to unhealthy food have not provided conclusive evidence. Review findings were mainly based on modeling of weight reduction based on assumption rather than on actual anthropometric measurements, which may require more research and longer duration to show impact. Focusing on the prices of one food item (SSB) may not draw a complete picture of changes in the entire diet which may contribute to shifts in food consumption within or across food categories.

Acknowledgment

The author is very thankful to all the associated personnel in any reference that contributed to/for this research.

Conflict of interest

This research holds no conflict of interest.

Author contribution

All authors have contributed to collecting and analyzing data and writing the manuscript. Zaghloul S was responsible for revising and editing the manuscript.

Sources of Support:

Academy for Scientific Research and Technology Project number: 5444.

6. References:

[1] GBD 2015 Obesity Collaborators. Health effects of overweight and obesity in 195 countries over 25 years. *New England Journal of Medicine*. 2017 Jul 6;377(1):13-27. doi.org/10.1056/nejmoa1614362 [PubMed] [Google Scholar].

[2] Hyseni L, Atkinson M, Bromley H, Orton L, Lloyd-Williams F, McGill R, et al. The effects of policy actions to improve population dietary patterns and prevent diet-related non-communicable diseases: scoping Review. *Eur J Clin Nutr*. 2017 Jun;71(6):694-711. doi.org/10.1038/ejcn.2016.234 [PubMed] [Google Scholar].

[3] World Health Organization. Regional framework for action on obesity prevention 2019-2023. World Health Organization. *Regional Office for the Eastern Mediterranean*; 2019 [Google Scholar].

[4] Javadinasab H, Masoudi Asl I, Vosoogh-Moghaddam A, Najafi B. Comparing selected countries using sin tax policy in sustainable health financing: Implications for developing countries. *Int J Health Plann Manage*. 2020 Jan;35(1):68-78. doi.org/10.1002/hpm.2817 [PubMed] [Google Scholar].

[5] World Bank. *Taxes on sugar-sweetened beverages: summary of international evidence and experiences*. 2020. doi.org/10.1596/33969 [Google Scholar].

[6] GBD 2015 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 79 behavioral, environmental and occupational, and metabolic risks or clusters of risks, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*. 2016 Oct 8;388(10053):1659-1724. doi.org/10.1016/S0140-6736(16)31679-8 [PubMed] [Google Scholar].

[7] The world health organization wants Sugar taxes, 2016. Available https://africa-health.com/news/world-health-organization-wants-sugar-taxes/.

[8] Scharf RJ, DeBoer MD. Sugar-Sweetened Beverages and Children's Health. *Annu Rev Public Health*. 2016;37:273-93. doi.org/10.1146/annurev-publhealth-032315-021528 [PubMed] [Google Scholar].

[9] World Health Organization. *Report of the commission on ending childhood obesity*. World Health Organization; 2016. [Google Scholar] [CrossRef].

[10] Alvarado M, Unwin N, Sharp SJ, Hambleton I, Murphy MM, Samuels TA, et al. Assessing the impact of the Barbados sugar-sweetened beverage tax on beverage sales: an observational

study. *Int J Behav Nutr Phys Act*. 2019 Jan 30;16(1):13. doi.org/10.1186/s12966-019-0776-7. [PubMed] [Google Scholar].

[11] Waterlander WE, Ni Mhurchu C, Steenhuis IH. Effects of a price increase on purchases of sugar sweetened beverages. Results from a randomized controlled trial. *Appetite*. 2014 Jul;78:32-9. doi.org/10.1016/j.appet.2014.03.012. [PubMed] [Google Scholar].

[12] Colchero MA, Popkin BM, Rivera JA, Ng SW. Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. *BMJ*. 2016 Jan 6;352:h6704. doi.org/10.1136/bmj.h6704. [PubMed] [Google Scholar].

[13] Falbe J, Thompson HR, Becker CM, Rojas N, McCulloch CE, Madsen KA. Impact of the Berkeley Excise Tax on Sugar-Sweetened Beverage Consumption. *Am J Public Health*. 2016 Oct;106(10):1865-71. doi.org/10.2105/AJPH.2016.303362 [PubMed] [Google Scholar].

[14] Etilé F, Sharma A. Do High Consumers of Sugar-Sweetened Beverages Respond Differently to Price Changes? A Finite Mixture IV-Tobit Approach. *Health Econ*. 2015 Sep;24(9):1147-63. doi.org/10.1002/hec.3157 [PubMed] [Google Scholar].

[15] Andreyeva T, Chaloupka FJ, Brownell KD. Estimating the potential of taxes on sugar-sweetened beverages to reduce consumption and generate revenue. *Prev Med*. 2011 Jun;52(6):413-6. doi.org/10.1016/j.ypmed.2011.03.013 [PubMed] [Google Scholar].

[16] Zhen C, Finkelstein EA, Nonnemaker J, Karns S, Todd JE. Predicting the Effects of Sugar-Sweetened Beverage Taxes on Food and Beverage Demand in a Large Demand System. *Am J Agric Econ*. 2014 Jan 1;96(1):1-25. doi.org/10.1093/ajae/aat049 [PubMed] [Google Scholar].

[17] Ruff RR, Zhen C. Estimating the effects of a calorie-based sugar-sweetened beverage tax on weight and obesity in New York City adults using dynamic loss models. *Ann Epidemiol*. 2015 May;25(5):350-7. doi.org/10.1016/j.annepidem.2014.12.008 [PubMed] [Google Scholar].

[18] Lin BH, Smith TA, Lee JY, Hall KD. Measuring weight outcomes for obesity intervention strategies: the case of a sugar-sweetened beverage tax. *Econ Hum Biol*. 2011 Dec;9(4):329-41. doi.org/10.1016/j.ehb.2011.08.007 [PubMed] [Google Scholar].

[19] Segovia J, Orellana M, Sarmiento JP, Carchi D. The effects of taxing sugar-sweetened beverages in Ecuador: An analysis across different income and consumption groups. *PLoS One*. 2020 Oct 13;15(10):e0240546. doi.org/10.1371/journal.pone.0240546 [PubMed] [Google Scholar].

[20] Dharmasena S, Capps O Jr. Intended and unintended consequences of a proposed national tax on sugar-sweetened beverages to combat the U.S. obesity problem. *Health Econ*. 2012 Jun;21(6):669-94. doi.org/10.1002/hec.1738 [PubMed] [Google Scholar].

[21] Long MW, Gortmaker SL, Ward ZJ, Resch SC, Moodie ML, Sacks G, et al. Cost Effectiveness of a Sugar-Sweetened Beverage Excise Tax in the U.S. *Am J Prev Med*. 2015 Jul;49(1):112-23. doi.org/10.1016/j.amepre.2015.03.004 [PubMed] [Google Scholar].

[22] Kristensen AH, Flottemesch TJ, Maciosek MV, Jenson J, Barclay G, Ashe M, et al. Reducing childhood obesity through U.S. federal policy: a microsimulation analysis. *Am J Prev Med*. 2014 Nov;47(5):604-12. doi.org/10.1016/j.amepre.2014.07.011 [PubMed] [Google Scholar].

[23] Gortmaker SL, Wang YC, Long MW, Giles CM, Ward ZJ, Barrett JL, et al. Three Interventions That Reduce Childhood Obesity Are Projected To Save More Than They Cost To Implement. *Health Aff (Millwood).* 2015 Nov;34(11):1932-9. doi.org/10.1377/hlthaff.2015.0631 [PubMed] [Google Scholar].

[24] Sharma A, Hauck K, Hollingsworth B, Siciliani L. The effects of taxing sugar-sweetened beverages across different income groups. *Health Econ*. 2014 Sep;23(9):1159-84. doi.org/10.1002/hec.3070 [PubMed] [Google Scholar].

[25] Basu S, Vellakkal S, Agrawal S, Stuckler D, Popkin B, Ebrahim S. Averting obesity and type 2 diabetes in India through sugar-sweetened beverage taxation: an economic-epidemiologic modeling study. *PLoS Med*. 2014 Jan;11(1):e1001582. doi.org/10.1371/journal.pmed.1001582. [PubMed] [Google Scholar]

[26] Manyema M, Veerman LJ, Tugendhaft A, Labadarios D, Hofman KJ. Modelling the potential impact of a sugar-sweetened beverage tax on stroke mortality, costs and health-adjusted life years in South Africa. *BMC Public Health*. 2016 May 31;16:405. doi.org/10.1186/s12889-016-3085-y [PubMed] [Google Scholar]

[27] Briggs AD, Mytton OT, Kehlbacher A, Tiffin R, Rayner M, Scarborough P. Overall and income specific effect on prevalence of overweight and obesity of 20% sugar sweetened drink tax in UK: econometric and comparative risk assessment modelling study. *BMJ*. 2013 October 31;347:f6189. doi.org/10.1136/bmj.f6189. [PubMed] [Google Scholar].

[28] Bhimjiyani A, Knuchel-Takano A. *Short and sweet: Why the government should introduce a sugary drinks tax.*: Cancer Research UK; 2016 [CrossRef].

[29] Schwendicke F, Stolpe M. Taxing sugar-sweetened beverages: impact on overweight and obesity in Germany. *BMC Public Health*. 2017 Jan 17;17(1):88. doi.org/10.1186/s12889-016-3938-4. [PubMed] [Google Scholar].

[30] Fletcher JM, Frisvold DE, Tefft N. Non-linear effects of soda taxes on consumption and weight outcomes. *Health Econ*. 2015 May;24(5):566-82. doi.org/10.1002/hec.3045 [PubMed] [Google Scholar].

[31] Cabrera Escobar MA, Veerman JL, Tollman SM, Bertram MY, Hofman KJ. Evidence that a tax on sugar sweetened beverages reduces the obesity rate: a meta-analysis. *BMC Public Health*. 2013 November 13;13:1072. doi.org/10.1186/1471-2458-13-1072 [PubMed] [Google Scholar].

[32] Nakhimovsky SS, Feigl AB, Avila C, O'Sullivan G, Macgregor-Skinner E, Spranca M. Taxes on Sugar-Sweetened Beverages to Reduce Overweight and Obesity in Middle-Income Countries: A Systematic Review. *PLoS One*. 2016 Sep 26;11(9):e0163358. doi.org/10.1371/journal.pone.0163358 [PubMed] [Google Scholar].

[33] Hangoma P, Bulawayo M, Chewe M, Stacey N, Downey L, Chalkidou K, et al. The potential health and revenue effects of a tax on sugar sweetened beverages in Zambia. *BMJ Glob Health*. 2020 Apr;5(4):e001968. doi.org/10.1136/bmjgh-2019-001968 [PubMed] [Google Scholar].

[34] Fernandez MA, Raine KD. Insights on the Influence of Sugar Taxes on Obesity Prevention Efforts. *Curr Nutr Rep*. 2019 Dec;8(4):333-339. doi.org/10.1007/s13668-019-00282-4 [PubMed] [Google Scholar].

[35] Bandy LK, Scarborough P, Harrington RA, Rayner M, Jebb SA. Reductions in sugar sales from soft drinks in the UK from 2015 to 2018. *BMC Med*. 2020 January 13;18(1):20. doi.org/10.1186/s12916-019-1477-4 [PubMed] [Google Scholar].

[36] Scarborough P, Adhikari V, Harrington RA, Elhussein A, Briggs A, Rayner M, et al. Impact of the announcement and implementation of the UK Soft Drinks Industry Levy on sugar content, price, product size and number of available soft drinks in the UK, 2015-19: A controlled interrupted time series analysis. *PLoS Med*. 2020 Feb 11;17(2):e1003025. doi.org/10.1371/journal.pmed.1003025 [PubMed] [Google Scholar].

[37] Working to Achieve A Healthier Future for Wales, public Health Wales 2018 https://phw.nhs.wales/files/annual-reports/working-to-achieve-a-healthier-future-for-wales-annual-report-2018-19/

[38] Al-Jawaldeh A, Megally R. Impact evaluation of national nutrition policies to address obesity through implementation of sin taxes in Gulf Cooperation Council countries: Bahrain, Saudi Arabia, Oman, United Arab Emirates, Kuwait and Qatar [version 1; peer. *F1000Research*. 2020 October 30;9:1287] doi.org/10.12688/f1000research.27097.1 [Google Scholar] [CrossRef].

[39] Asfaw A. The role of food price policy in determining the prevalence of obesity: evidence from Egypt. *Review of Agricultural Economics*. 2006 Oct 1;28(3):305-12 doi.org/10.1111/j.1467-9353.2006.00291.x [Google Scholar] [CrossRef].

[40] Ecker O, Al-Riffai P, Breisinger C, El-Batrawy R. Nutrition and economic development: Exploring Egypt's exceptionalism and the role of food subsidies. *Intl Food Policy Res Inst*; 2016 November 15. doi.org/10.2499/9780896292482 [Google Scholar] [CrossRef].

[41] Ismail MS, Qahiz NM. Can Dietary Calcium Consumption be Beneficial in Body Weight Loss Regimen? *Merit Res. J. Med. Med. Sci*. 2016;4:282-9 [Google Scholar] [CrossRef].

[42] Ni Mhurchu C, Blakely T, Jiang Y, Eyles HC, Rodgers A. Effects of price discounts and tailored nutrition education on supermarket purchases: a randomized controlled trial. *Am J Clin Nutr*. 2010 Mar;91(3):736-47. doi.org/10.3945/ajcn.2009.28742 [PubMed] [Google Scholar].

[43] Blakely T, Ni Mhurchu C, Jiang Y, Matoe L, Funaki-Tahifote M, Eyles HC, et al. Do effects of price discounts and nutrition education on food purchases vary by ethnicity, income and education? Results from a randomised, controlled trial. *J Epidemiol Community Health*. 2011 Oct;65(10):902-8. doi.org/10.1136/jech.2010.118588 [PubMed] [Google Scholar].

[44] An R. Effectiveness of subsidies in promoting healthy food purchases and consumption: a review of field experiments. *Public Health Nutr*. 2013 Jul;16(7):1215-28. doi.org/10.1017/S1368980012004715 [PubMed] [Google Scholar].

[45] Burr ML, Trembeth J, Jones KB, Geen J, Lynch LA, Roberts ZE. The effects of dietary advice and vouchers on the intake of fruit and fruit juice by pregnant women in a deprived area: a controlled trial. *Public Health Nutr*. 2007 Jun;10(6):559-65. doi.org/10.1017/S1368980007249730 [PubMed] [Google Scholar].

[46] Kennedy BM, Champagne CM, Ryan DH, Newton R Jr, Conish BK, Harsha DW, et al. Lower Mississippi Delta Nutrition Intervention Research; Initiative. The "Rolling Store:" an economical and environmental approach to the prevention of weight gain in African American women. *Ethn Dis*. 2009 Winter;19(1):7-12. PMID: 19341156 [PubMed] [Google Scholar].

[47] Bihan H, Méjean C, Castetbon K, Faure H, Ducros V, Sedeaud A, et al. Impact of fruit and vegetable vouchers and dietary advice on fruit and vegetable intake in a low-income population. *Eur J Clin Nutr*. 2012 Mar;66(3):369-75. doi.org/10.1038/ejcn.2011.173 [PubMed] [Google Scholar].

[48] Herman DR, Harrison GG, Afifi AA, Jenks E. Effect of a targeted subsidy on intake of fruits and vegetables among low-income women in the Special Supplemental Nutrition Program for Women, Infants, and Children. *Am J Public Health*. 2008 Jan;98(1):98-105. doi.org/10.2105/AJPH.2005.079418 [PubMed] [Google Scholar].

[49] Sadeghirad B, Duhaney T, Motaghipisheh S, Campbell NR, Johnston BC. Influence of unhealthy food and beverage marketing on children's dietary intake and preference: a

systematic review and meta-analysis of randomized trials. *Obes Rev*. 2016 Oct;17(10):945-59. doi.org/10.1111/obr.12445 [PubMed] [Google Scholar].

[50] Norman J, Kelly B, McMahon AT, Boyland E, Baur LA, Chapman K, et al. Sustained impact of energy-dense TV and online food advertising on children's dietary intake: a within-subject, randomised, crossover, counter-balanced trial. *Int J Behav Nutr Phys Act*. 2018 Apr 12;15(1):37. doi.org/10.1186/s12966-018-0672-6 [PubMed] [Google Scholar].

[51] Al-Ghannami S, Al-Shammakhi S, Al Jawaldeh A, Al-Mamari F, Al Gammaria I, Al-Aamry J, et al. Rapid assessment of marketing of unhealthy foods to children in mass media, schools and retail stores in Oman. *East Mediterr Health J.* 2019 November 25;25(11):820-827. doi.org/10.26719/emhj.19.066 [PubMed] [Google Scholar].

[52] Taillie LS, Hall MG, Popkin BM, Ng SW, Murukutla N. Experimental Studies of Front-of-Package Nutrient Warning Labels on Sugar-Sweetened Beverages and Ultra-Processed Foods: A Scoping Review. *Nutrients*. 2020 Feb 22;12(2):569. doi.org/10.3390/nu12020569 [PubMed] [Google Scholar].

[53] Taillie LS, Reyes M, Colchero MA, Popkin B, Corvalán C. An evaluation of Chile's Law of Food Labeling and Advertising on sugar-sweetened beverage purchases from 2015 to 2017: A before-and-after study. *PLoS Med*. 2020 Feb 11;17(2):e1003015. doi.org/10.1371/journal.pmed.1003015 [PubMed] [Google Scholar].

[54] Silva A, Higgins LM, Hussein M. An evaluation of the effect of child-directed television food advertising regulation in the United Kingdom. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*. 2015 Dec;63(4):583-600. doi.org/10.1111/cjag.12078 [Google Scholar] [CrossRef].

[55] Dhar T, Baylis K. Fast-food consumption and the ban on advertising targeting children: the Quebec experience. *Journal of Marketing Research*. 2011 Oct;48(5):799-813. doi.org/10.1509/jmkr.48.5.799 [Google Scholar] [CrossRef].

[56] Kim S, Lee Y, Yoon J, Chung SJ, Lee SK, Kim H. Restriction of television food advertising in South Korea: impact on advertising of food companies. *Health Promot Int*. 2013 Mar;28(1):17-25. doi.org/10.1093/heapro/das023 [PubMed] [Google Scholar].

[57] Chandon P, Wansink B. Does food marketing need to make us fat? A review and solutions. *Nutr Rev*. 2012 Oct;70(10):571-93. doi.org/10.1111/j.1753-4887.2012.00518.x [PubMed] [Google Scholar].

[58] Vandevijvere S, Swinburn B; International Network for Food and Obesity/non-communicable diseases (NCDs) Research, Monitoring and Action Support (INFORMAS). Towards global benchmarking of food environments and policies to reduce obesity and diet-related non-communicable diseases: design and methods for nation-wide surveys. *BMJ Open*. 2014 May 15;4(5):e005339. doi.org/10.1136/bmjopen-2014-005339 [PubMed] [Google Scholar].

[59] Rincón-Gallardo PS, Carriedo A, Tolentino-Mayo L, Allemandi L, Tiscornia V, Araneda J, et al. *Review of current labelling regulations and practices for food and beverage targeting children and adolescents in Latin America countries (Mexico, Chile, Costa Rica and Argentina) and recommendations for facilitating consumer*. United Nations Children's Fund. Nueva York: UNICEF. 2016 [Google Scholar] [CrossRef].

[60] Basto-Abreu A, Torres-Alvarez R, Reyes-Sánchez F, González-Morales R, Canto-Osorio F, Colchero MA, et al. Predicting obesity reduction after implementing warning labels in Mexico: A modeling study. *PLoS Med*. 2020 Jul 28;17(7):e1003221. doi.org/10.1371/journal.pmed.1003221 [PubMed] [Google Scholar].

[61] Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev Med*. 1999 Dec;29(6 Pt 1):563-70. doi.org/10.1006/pmed.1999.0585 [PubMed] [Google Scholar].

[62] Gauthier KI, Krajicek MJ. Obesogenic environment: a concept analysis and pediatric perspective. *J Spec Pediatr Nurs*. 2013 Jul;18(3):202-10. doi.org/10.1111/jspn.12027 [PubMed] [Google Scholar].

[63] Kaczynski AT, Eberth JM, Stowe EW, Wende ME, Liese AD, McLain AC, et al. Development of a national childhood obesogenic environment index in the United States: differences by region and rurality. *Int J Behav Nutr Phys Act*. 2020 Jul 2;17(1):83. doi.org/10.1186/s12966-020-00984-x [PubMed] [Google Scholar].

[64] Frongillo EA, Fawcett SB, Ritchie LD, Sonia Arteaga S, Loria CM, Pate RR, John LV, et al. Community Policies and Programs to Prevent Obesity and Child Adiposity. *Am J Prev Med*. 2017 Nov;53(5):576-583. doi.org/10.1016/j.amepre.2017.05.006 [PubMed] [Google Scholar].

[65] Alkhateib[1] M, Elzoghbi M, Saleh M, Qotba H. Influence of sedentary lifestyle on body weight in Qatari school children. *J. Saudi Soc. for Food and Nutrition*, Vol. No. 1&2;2013, 16-29 [Google Scholar] [CrossRef].

[66] Al-Mohaimeed A, Ismail MS, Dandash K, Ahmed SM, AlHarbi MH. Progressive changes in overweight and obesity during the early years of schooling among children in a central region of Saudi Arabia. *Food and Public Health*. 2012;2(5):159-67. doi.org/10.5923/j.fph.2020205.07 [Google Scholar] [CrossRef].

[67] Haire-Joshu D, Nanney MS, Elliott M, Davey C, Caito N, Loman D, et al. The use of mentoring programs to improve energy balance behaviors in high-risk children. *Obesity (Silver Spring)*. 2010 Feb;18 Suppl 1(0 1):S75-83. doi.org/10.1038/oby.2009.435 [PubMed] [Google Scholar].

[68] Al-Mohaimeed A, Ahmed S, Dandash K, Ismail MS, Saquib N. Concordance of obesity classification between body mass index and percent body fat among school children in Saudi Arabia. *BMC pediatrics*. 2015 Dec;15(1):1-5 [PubMed] [Google Scholar].

[69] Brown EC, Buchan DS, Baker JS, Wyatt FB, Bocalini DS, Kilgore L. A Systematised Review of Primary School Whole Class Child Obesity Interventions: Effectiveness, Characteristics, and Strategies. *Biomed Res Int*. 2016;2016:4902714. doi.org/10.1155/2016/4902714 [PubMed] [Google Scholar].

[70] Bleich SN, Vercammen KA, Zatz LY, Frelier JM, Ebbeling CB, Peeters A. Interventions to prevent global childhood overweight and obesity: a systematic review. *Lancet Diabetes Endocrinol*. 2018 Apr;6(4):332-346. doi.org/10.1016/S2213-8587(17)30358-3 [PubMed] [Google Scholar].

[71] Bramante CT, Thornton RLJ, Bennett WL, Zhang A, Wilson RF, Bass EB, Tseng E. Systematic Review of Natural Experiments for Childhood Obesity Prevention and Control. *Am J Prev Med*. 2019 Jan;56(1):147-158. doi.org/10.1016/j.amepre.2018.08.023 [PubMed] [Google Scholar].

[72] de Sa J, Lock K. Will European agricultural policy for school fruit and vegetables improve public health? A review of school fruit and vegetable programmes. *Eur J Public Health*. 2008 Dec;18(6):558-68. doi.org/10.1093/eurpub/ckn061 [PubMed] [Google Scholar].

[73] Hersch D, Perdue L, Ambroz T, Boucher JL. The impact of cooking classes on food-related preferences, attitudes, and behaviors of school-aged children: a systematic review of the

evidence, 2003-2014. *Prev Chronic Dis*. 2014 Nov 6;11:E193. doi.org/10.5888/pcd11.140267 [PubMed] [Google Scholar].

[74] Driessen CE, Cameron AJ, Thornton LE, Lai SK, Barnett LM. Effect of changes to the school food environment on eating behaviours and/or body weight in children: a systematic review. *Obes Rev*. 2014 Dec;15(12):968-82. doi.org/10.1111/obr.12224 [PubMed] [Google Scholar].

[75] Aloia CR, Shockey TA, Nahar VK, Knight KB. Pertinence of the recent school-based nutrition interventions targeting fruit and vegetable consumption in the United States:a systematic review. *Health Promot Perspect*. 2016 Mar 31;6(1):1-9. doi.org/10.15171/hpp.2016.01 [PubMed] [Google Scholar].

[76] Avery A, Bostock L, McCullough F. A systematic review investigating interventions that can help reduce consumption of sugar-sweetened beverages in children leading to changes in body fatness. *J Hum Nutr Diet*. 2015 Jan;28 Suppl 1(Suppl 1):52-64. doi.org/10.1111/jhn.12267 [PubMed] [Google Scholar].

[77] Oosterhoff M, Joore M, Ferreira I. The effects of school-based lifestyle interventions on body mass index and blood pressure: a multivariate multilevel meta-analysis of randomized controlled trials. *Obes Rev*. 2016 Nov;17(11):1131-1153. doi.org/10.1111/obr.12446 [PubMed] [Google Scholar].

[78] Salam RA, Hooda M, Das JK, Arshad A, Lassi ZS, Middleton P, Bhutta ZA. Interventions to Improve Adolescent Nutrition: A Systematic Review and Meta-Analysis. *J Adolesc Health*. 2016 Oct;59(4S):S29-S39. doi.org/10.1016/j.jadohealth.2016.06.022 [PubMed] [Google Scholar].

[79] USDA. Chapter 4-D. *Food Environment. In: A Series of Systematic Reviews on the Effects of Nutrition Education on Children's and Adolescents' Dietary Intake*. Virginia: U.S. Department of Agriculture; 2012 (https://nesr.usda.gov/sites/default/files/2019-04/NutritionEducation-FullReport.pdf)

[80] Nekitsing C, Blundell-Birtill P, Cockroft JE, Hetherington MM. Systematic Review and meta-analysis of strategies to increase vegetable consumption in preschool children aged 2-5 years. *Appetite*. 2018 August 1;127:138-154. doi.org/10.1016/j.appet.2018.04.019 [PubMed] [Google Scholar].

[81] Knai C, Pomerleau J, Lock K, McKee M. Getting children to eat more fruit and vegetables: a systematic review. *Prev Med*. 2006 Feb;42(2):85-95. doi.org/10.1016/j.ypmed.2005.11.012 [PubMed] [Google Scholar].

[82] Langford R, Bonell CP, Jones HE, Pouliou T, Murphy SM, Waters E, et al. The WHO Health Promoting School framework for improving the health and well-being of students and their academic achievement. *Cochrane Database Syst Rev*. 2014 April 16;(4):CD008958. doi.org/10.1002/14651858.CD008958.pub2 [PubMed] [Google Scholar].

[83] Lavelle HV, Mackay DF, Pell JP. Systematic Review and meta-analysis of school-based interventions to reduce body mass index. *J Public Health (Oxf)*. 2012 Aug;34(3):360-9. doi.org/10.1093/pubmed/fdr116 [PubMed] [Google Scholar].

[84] Katz DL, O'Connell M, Njike VY, Yeh MC, Nawaz H. Strategies for the prevention and control of obesity in the school setting: systematic Review and meta-analysis. *Int J Obes (Lond)*. 2008 Dec;32(12):1780-9. doi.org/10.1038/ijo.2008.158 [PubMed] [Google Scholar].

[85] Williams AJ, Henley WE, Williams CA, Hurst AJ, Logan S, Wyatt KM. Systematic Review and meta-analysis of the association between childhood overweight and obesity and primary

school diet and physical activity policies. *Int J Behav Nutr Phys Act*. 2013 August 22;10:101. doi.org/10.1186/1479-5868-10-101 [PubMed] [Google Scholar].

[86] Sacco J, Lillico HG, Chen E, Hobin E. The influence of menu labelling on food choices among children and adolescents: a systematic review of the literature. *Perspect Public Health*. 2017 May;137(3):173-181. doi.org/10.1177/1757913916658498 [PubMed] [Google Scholar].

[87] Silveira JA, Taddei JA, Guerra PH, Nobre MR. The effect of participation in school-based nutrition education interventions on body mass index: a meta-analysis of randomized controlled community trials. *Prev Med*. 2013 Mar;56(3-4):237-43. doi.org/10.1016/j.ypmed.2013.01.011 [PubMed] [Google Scholar].

[88] Sobol-Goldberg S, Rabinowitz J, Gross R. School-based obesity prevention programs: a meta-analysis of randomized controlled trials. *Obesity (Silver Spring).* 2013 Dec;21(12):2422-8. doi.org/10.1002/oby.20515 [PubMed] [Google Scholar].

[89] Niebylski ML, Lu T, Campbell NR, Arcand J, Schermel A, Hua D, et al. Healthy food procurement policies and their impact. *Int J Environ Res Public Health*. 2014 Mar 3;11(3):2608-27. doi.org/10.3390/ijerph110302608 [PubMed] [Google Scholar].

[90] Mayne SL, Auchincloss AH, Michael YL. Impact of policy and built environment changes on obesity-related outcomes: a systematic review of naturally occurring experiments. *Obes Rev*. 2015 May;16(5):362-75. doi.org/10.1111/obr.12269 [PubMed] [Google Scholar].

[91] von Philipsborn P, Stratil JM, Burns J, Busert LK, Pfadenhauer LM, Polus S, et al. Environmental interventions to reduce the consumption of sugar-sweetened beverages and their effects on health. *Cochrane Database Syst Rev*. 2019 June 12;6(6):CD012292. doi.org/10.1002/14651858.CD012292.pub2 [PubMed] [Google Scholar].

[92] Miyawaki A, Lee JS, Kobayashi Y. Impact of the school lunch program on overweight and obesity among junior high school students: a nationwide study in Japan. *J Public Health (Oxf).* 2019 Jun 1;41(2):362-370. doi.org/10.1093/pubmed/fdy095 [PubMed] [Google Scholar].

[93] Ickovics JR, Duffany KO, Shebl FM, Peters SM, Read MA, Gilstad-Hayden KR, et al. Implementing School-Based Policies to Prevent Obesity: Cluster Randomized Trial. *Am J Prev Med*. 2019 Jan;56(1):e1-e11. doi.org/10.1016/j.amepre.2018.08.026 [PubMed] [Google Scholar].

[94] Lambrinou CP, Androutsos O, Karaglani E, Cardon G, Huys N, Wikström K, et al. Effective strategies for childhood obesity prevention via school based, family involved interventions: a critical review for the development of the Feel4Diabetes-study school based component. *BMC Endocr Disord*. 2020 May 6;20(Suppl 2):52. doi.org/10.1186/s12902-020-0526-5 [PubMed] [Google Scholar].

[95] Matsuzaki M, Sánchez BN, Rebanal RD, Gittelsohn J, Sanchez-Vaznaugh EV. California and federal school nutrition policies and obesity among children of Pacific Islander, American Indian/Alaska Native, and Filipino origins: Interrupted time series analysis. *PLoS Med*. 2021 May 24;18(5):e1003596. doi.org/10.1371/journal.pmed.1003596 [PubMed] [Google Scholar].

[96] Habib-Mourad C, Ghandour LA, Maliha C, Dagher M, Kharroubi S, Hwalla N. Impact of a Three-Year Obesity Prevention Study on Healthy Behaviors and BMI among Lebanese Schoolchildren: Findings from Ajyal Salima Program. *Nutrients*. 2020 Sep 3;12(9):2687. doi.org/10.3390/nu12092687 [PubMed] [Google Scholar].