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EFFECTIVENESS OF OBESITY PREVENTION AND CONTROL

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Abstract

Implementation of evidence-based interventions to control obesity is regarded as a public health priority. In this working paper, effectiveness and cost-effectiveness evidence of sugar-sweetened beverage (SSB) taxes, nutrition labeling, advertising bans on unhealthy food, and school-based interventions are reviewed.

The review indicates that SSB taxes may be an effective and cost-effective intervention for obesity prevention and control. Regarding nutrition labeling, current evidence indicates that this has a significant impact on food selection. Although there is limited evidence on its impact on body mass index (BMI) and obesity prevalence, nutrition labeling is considered a cost-effective intervention in many settings. Further, while current evidence indicates that unhealthy food and beverage advertisements may increase dietary intake and the preference for unhealthy foods, especially in children, limited evidence demonstrates the impact of restricted unhealthy food advertising on BMI and obesity prevalence. However, such an intervention is considered to be cost-effective in many settings. Concerning school-based interventions, due to the limited number of good-quality studies as well as high variation across studies, the effectiveness of these interventions is inconclusive. Current evidence also suggests that school-based interventions are less likely to be cost-effective.

JEL Classification: I12, I18

Contents

1. INTRODUCTION

Obesity, a global health concern, is defined as having a body mass index (BMI) greater than or equal to 30 kilograms per square meter (kg/m^2). According to the World Health Organization (WHO), in 2014, 1.9 billion adults were overweight (i.e., had a BMI of 25–30 kg/m^2) while 600 million were obese (i.e., had a BMI of 30 kg/m^2 or more). In addition, about 41 million children under age 5 years were considered overweight or obese (WHO 2016).

The prevalence of obesity and overweight is high and is increasing worldwide. The prevalence in adults increased from 28.8% in 1980 to 36.9% in 2013 for men, and from 29.8% to 38.0% for women (Ng et al. 2014). Among children and adolescents, in 2013, 23.8% of boys and 22.6% of girls in developed countries were considered overweight or obese, as compared to 12.9% of boys and 13.4% of girls in developing countries (Ng et al. 2014). The majority of overweight and obese children live in developing countries, where the prevalence of obesity is increasing at a higher rate than in developed countries (WHO 2014).

Strong and consistent evidence indicates the negative health impacts of overweight and obesity. Obesity is an independent risk factor for many noncommunicable diseases such as type 2 diabetes, coronary heart disease, stroke, gallbladder disease, osteoarthritis, some types of cancers, and sleep apnea (Guh 2009, Luppino 2010). In addition, a positive relationship seems to exist between overweight and obesity and all causes of mortality (The Global BMI Mortality Collaboration 2016). In 2010, about 3.4 million deaths were caused by obesity and overweight, resulting in 3.8% global disability-adjusted life years (DALYs) (Lim et al. 2012).

In addition to its negative impact on health outcomes, obesity imposes a substantial economic burden. Evidence consistently indicates that health care costs of an overweight and obese individual are higher than those of the general population (Colagiuri et al. 2010, Hoque et al. 2016). One systematic review revealed that obesity accounts for 0.7%–2.8% of a country's total health expenditures (Withrow and Alter 2011). Another review in 10 European countries indicated that the cost of obesity is responsible for 0.09%–0.61% of the gross domestic product (Müller-Riemenschneider 2008). Several studies have also examined the economic cost of obesity in Asia-Pacific countries (Ko 2008, Zhao 2008, Pitayatienanan et al. 2014), while a recent systematic review (Hoque 2016) identified 13 articles examining the economic burden of obesity in Australia; the People's Republic of China (PRC); Hong Kong, China; Japan, the Republic of Korea; New Zealand; Taipei,China; and Thailand. It revealed that overweight and obesity was responsible for 1.5%–9.9% of their total health expenditures.

Generally, obesity and overweight are caused by an energy imbalance that occurs when energy intake is greater than energy expenditure over a prolonged period of time, resulting in the accumulation of excess body fat. The intake of high-density energy food, especially sugars and fats, and an increasingly sedentary lifestyle due to increased urbanization, are two main factors contributing to the increased prevalence of obesity worldwide (Powell et al. 2014).

In response to the obesity epidemic and negative consequences of obesity on health and the economy, the prevention and control of obesity have become a high priority for public health. Since the etiology of obesity is complex, a variety of interventions aimed to prevent and control obesity has been developed. These interventions mainly target increasing physical activity levels, decreasing energy-dense food consumption,

and increasing fruit and vegetable consumption. Examples include those that aim to improve diet and/or physical activity through schools, primary care clinics, child care settings, communities, or workplaces; focus on food policy and regulation (e.g., taxation of unhealthy foods, marketing restrictions on unhealthy foods, labeling regulations, and fruit and vegetable subsidies); and promote walking, cycling, and using public transport for commuting. Implementation of these interventions is regarded as a public health priority, so evidence on effectiveness is necessary.

This paper reviews the current state of knowledge on the effectiveness of selected interventions that focus on obesity prevention and control. Given the large volume of studies examining the effectiveness of interventions and that systematic reviews and meta-analyses are key to evidence-based medicine and policy decision making, this paper focuses on, but is not limited to, evidence reported in systematic reviews, meta-analyses, and reviews of systematic reviews and meta-analyses. Since cost-effective analysis is an important tool in prioritizing interventions for obesity prevention, where available, evidence on cost-effectiveness is also summarized. Knowledge gaps regarding the effectiveness of such interventions are also discussed.

Among several interventions, the role of sugar-sweetened beverages (SSBs) in increasing body weight and obesity has recently received much attention. There is a debate regarding SSB consumption and obesity, as well as the effectiveness of SSB taxes as an obesity prevention tool. Similarly, nutrition labeling and advertising bans on unhealthy food are regarded as suitable food policies by many governments to tackle the obesity epidemic (OECD 2014). With regard to childhood obesity, school-based interventions are popular (WHO 2009). Therefore, these interventions were selected for this paper.

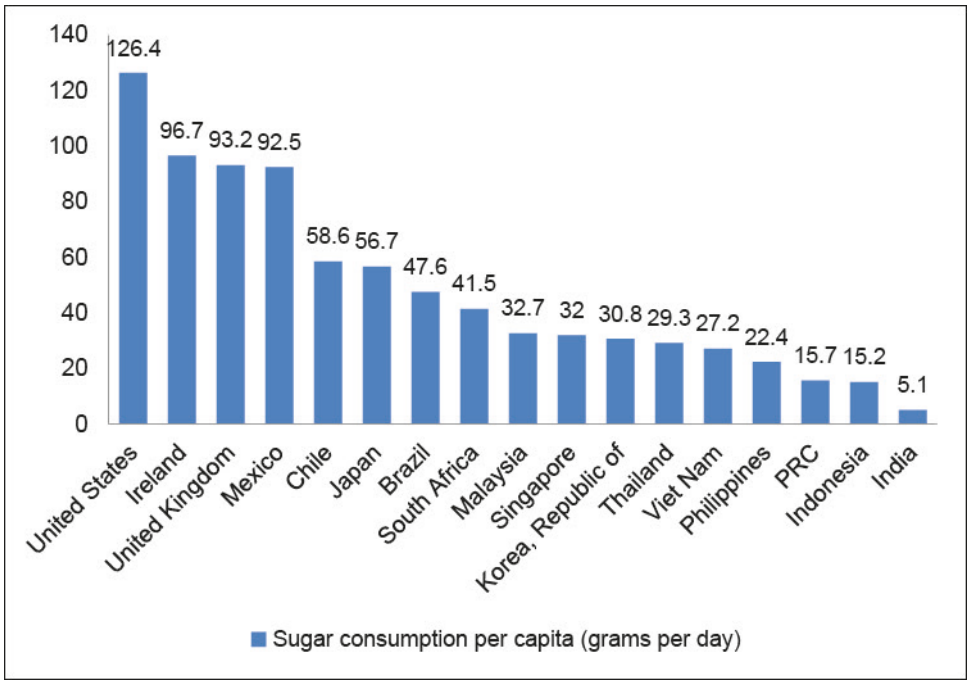
2. SUGAR-SWEETENED BEVERAGE TAXES

According to WHO (2015), “free sugar” is all monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook, or consumer, as well as sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates. Since 2002, WHO (2015) has recommended that free sugar intake be reduced to less than 10% of total energy intake, and a further reduction to below 5% was recommended for additional benefits. Based on this recommendation, the amount of sugar consumed by typical adults should not exceed 6 teaspoons or 25 grams per day. According to the Euromonitor International (2015), the highest per capita sugar consumption can be found in the United States (see figure below).

Although sugars are found naturally in many foods and food products, a leading source of added sugar intake is the consumption of SSBs. In the United States, about 50% of the added sugar consumed is from SSBs (Welsh et al. 2011). SSBs include soft drinks, fruit drinks, sport drinks, as well as energy drinks that contain added sugar. Generally, a single 330-milliliter can of a sugar-sweetened carbonated soft drink contains 35 grams of added sugar, which exceeds the recommended limit of sugar intake per day by WHO (WHO 2015).

Globally, the current consumption of SSBs is high. A recent study examining SSB sales indicated that the four regions with the highest reported consumption are North America, Latin America, Australia, and Western Europe, while the lowest reported consumption is the Asia-Pacific region (Popkin and Hawkes 2016). However, SSB sales (in calories per person) are increasing in many low- and middle-income countries and decreasing in high-income countries (Popkin and Hawkes 2016).

Sugar Consumption per Capita in Selected Countries
(grams per day)



Note: PRC = People's Republic of China.
Source: Euromonitor International (2015).

According to the Global School-Based Student Health Survey, the percentage of students aged 13–15 years who drank carbonated soft drinks at least once per day during the past 30 days is high in many developing countries (Table 1). Indeed, a recent study examining SSB consumption and obesity among adolescents in Pacific island countries and territories found that 37% of students aged 13–15 years reported that they consumed at least one carbonated soft drink per day over the past 30 days (Kessaram et al. 2015).

Table 1: Students Aged 13–15 Years Who Drink Carbonated Soft Drinks One or More Times per Day in Selected Developing Countries

Country	Year of Survey	% of Students
Brunei Darussalam	2014	46.30
Cambodia	2013	45.60
Indonesia	2015	28.80
Malaysia	2012	31.30
Philippines	2011	42.20
Samoa	2011	53.50
Solomon Islands	2011	45.10
Thailand	2015	57.70
Viet Nam	2013	34.60

Note: During the past 30 days.
Source: WHO. Global School-Based Student Health Survey (GSHS). http://www.who.int/chp/gshs/en/ (accessed 10 August 2016).

2.1 Sugar-Sweetened Beverages and Obesity Risk

Several studies have been conducted on the association between SSBs and obesity, but the findings have been inconclusive. Previously, a WHO-commissioned meta-analysis of randomized, controlled trial studies found that reducing added sugar intake lowers body weight by 0.8 kilogram (95% CI: 0.39–1.21) (Te Morenga et al. 2012).

In 2015, Keller and Bucher Della Torre (2015) examined 13 systematic reviews on the relationship between SSBs and obesity in children. The quality of the included studies was low to moderate, and 9 indicated a positive association between SSBs and obesity. The two studies with the highest-quality methodology (i.e., Kaiser et al. 2013, Mailk et al. 2013) reported conflicting findings; Kaiser et al. (2013) found inconclusive results, while Malik et al. (2013) found positive results regarding the relationship between SSBs and obesity. Later, the authors stated that the discrepancies may be explained by the fact that Malik et al. (2013) included both experimental (n = 5) and observational studies (n = 14), while Kaiser et al. (2013) included only experimental studies (n = 3). In addition, one out of three experimental studies in Kaiser et al. (2013) was not intended to examine the association between SSBs and obesity. All three experimental studies included had shorter durations than the studies found in Malik et al. (2013); a short-duration study may not be appropriate to assess the effect of interventions designed to detect weight loss.

Bes-Rastrollo et al. (2016) identified 23 systematic reviews (including 6 meta-analyses) through August 2015 that examined the relationship between SSBs and obesity. It found that the majority of studies, especially recent ones with strong methodologies, were more likely to identify the positive relationship between SSB consumption and obesity. Similarly, Bucher Della Torre et al. 2016 revealed that high-quality studies are more likely to suggest a positive relationship between SSB consumption and obesity.

It should also be noted that conflicts of interest impacted the findings of studies examining the relationship between SSBs and obesity. Bes-Rastrollo et al. (2016) indicated that industry-funded reviews are about five times more likely to demonstrate an insignificant relationship between SSB consumption and obesity than those without industry funding (relative risk: 5.3; 95% CI: 1.3–21.7). Similarly, a recent study examining the characteristics of 20 reviews (i.e., 5 meta-analyses, 3 qualitative systematic reviews, and 12 qualitative nonsystematic reviews) on the relationship between SSBs and obesity found that industry-funded reviews are more likely to indicate a weaker association between SSBs and obesity, whereas a stronger association was identified in reviews funded by other sources (Massougbodji et al. 2014).

WHO has expressed concern that the increasing intake of free sugars, particularly in the form of SSBs, may increase the prevalence of obesity. In 2013, the WHO Global Action Plan (2013) encouraged member states to consider implementing taxes that discourage the consumption of less healthy foods, including SSBs.

2.2 Effectiveness of Sugar-Sweetened Beverage Taxes

Based on the lessons of tobacco taxes, which successfully reduced the prevalence of smoking, SSB taxation has been suggested to reduce obesity prevalence. Governments in Australia, Fiji, Finland, France, Ireland, Mexico, Nauru, Samoa, and Sweden have already implemented such taxes.

Cabrera Escobar et al. (2013) conducted a meta-analysis of the impact of SSB taxes on SSB consumption and obesity. They identified nine articles published between 2008 and 2013, which contained studies conducted in the United States (6 studies), Brazil (1 study), France (1 study), and Mexico (1 study). In all, the price elasticity of demand (i.e., the change in consumer consumption with respect to changes in prices) was estimated.[1] All studies indicated negative own-price elasticity, as higher SSB prices led to lower SSB consumption. The pool own-price elasticity was –1.299 (95% CI: –1.089 to –1.509), denoting that a 10% increase in a tax would reduce SSB consumption by 12.99%. With respect to the impact of taxes on obesity, studies conducted in the United States found that a 1% increase in SSB prices can reduce obesity prevalence in adults and children by 0.0001 (Fleetcher et al. 2010) and 0.0090 (Fletcher et al. 2010), respectively. Another study in the United States indicated that a 10% increase in SSB prices can reduce obesity prevalence in men and women by 0.05 and 0.34, respectively (Han and Powell 2011), while a third study indicated that a 20% increase in SSB prices can reduce obesity prevalence by 0.0300 (Smith et al. 2010).

More studies in Australia, India, Ireland, South Africa, and the United States have been conducted to examine the impact of SSB taxes on SSB consumption and obesity (Table 2). All, except Falbe et al. (2016) included modeling techniques that used price elasticity in demand to estimate the reduction of SSB consumption leading to reduced energy intake. Based on changes in energy intake, the changes in body weight and obesity prevalence were estimated.

Table 2: Impact of Sugar-Sweetened Beverage Taxation on Sugar-Sweetened Beverage Consumption and Obesity

Study	Setting	Study Design and Assumptions	Effects of Taxes
Basu et al. (2014)	India	Method: Modeling Own-Price Elasticity: –0.94 (95% CI: –0.90 to –0.98)	A 20% SSB tax leads to • 3% reduction in overweight and obesity prevalence (95% CI: 1.6%–5.9%), and • 1.6% reduction in type-2 diabetes incidence (95% CI: 1.2%–1.9%). The largest effect was found in rural young men.
Briggs et al. (2013b)	Ireland	Pass-on Rate: 90% Method: Modeling Own-Price Elasticity: –0.90	A 10% SSB tax leads to • 1.3% reduction in obesity prevalence in adults, and • 0.7% reduction in overweight prevalence in adults. No significant differences across gender or income were identified. However, the impact on young adults was greater than on older adults.

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[1] Highly negative elasticity of demand means that an increase in product price will lead to a high reduction in consumption.

Table 2 *continued*

Study	Setting	Study Design and Assumptions	Effects of Taxes
Briggs et al. (2013a)	United Kingdom	Method: Modeling Own-Price Elasticity: –0.92	A 20% SSB tax leads to • reduced consumption of concentrated SSBs by 15% and nonconcentrated SSBs by 16%, • 1.3% reduction in obesity prevalence in adults (95% CI: 0.8%–1.7%), • 0.9% (95% CI: 0.6%–1.1%) reduction in overweight prevalence in adults, and • increase in tax revenue of £276 million annually. No significant differences across income were identified. However, the impact on children was more promising than on adults. A 10% SSB tax had approximately half of the effect of a 20% tax.
Manyema et al. (2014)	South Africa	Pass-on Rate: 100% Method: Modeling Own-Price Elasticity: –1.30 (assumed from systematic review)	A 20% SSB tax leads to • 3.8% reduction in obesity prevalence (95% CI: 0.6%–7.1%) in men, and • 2.4% reduction in obesity prevalence (95% CI: 0.4%–4.4%) in women.
Veerman et al. (2016)	Australia	Pass-on Rate: 100% Method: Modeling Own-Price Elasticity: –0.63	A 20% SSB tax leads to • reduced consumption of SSBs from 141 g/day to 124 g/day in men and from 76 g/day to 68 g/day in women; • 2.7% and 1.2% reductions in obesity prevalence in men and women, respectively; • 16,000 fewer new cases of type 2 diabetes, 4,400 fewer new cases of ischemic heart disease, and 1,100 fewer new cases of stroke (after 25 years of tax implementation); and • increase in tax revenue of A$400 million annually.
Falbe et al. (2016)	Berkeley, California	Method: Pre-Post Design	An SSB tax ($0.01 per ounce) is associated with lower SSB consumption.

g = gram, SSB = sugar-sweetened beverage.

A systematic review of SSB taxes intended to reduce overweight and obesity in middle-income countries was also recently conducted (Nakhimovsky et al. 2016). Nine studies conducted in Brazil, Ecuador, India, Mexico, Peru, and South Africa were included. This review looked at seven studies that were not included in Cabrera Escobar et al. (2013). Of the nine studies, four were observational studies, three were quasi-experimental studies, and two were modeling studies. All were published between 2008 and 2016. Based on the systemic review, SSB taxes led to increased

SSB prices, which resulted in reduced SSB consumption. The review found that the own-price elasticity of SSBs ranged from –0.6 to –1.2, concluding that taxes can be an effective tool to control obesity in middle-income countries—even in India, where obesity prevalence and SSB consumption are lower than other middle-income or developed countries. However, the authors stated that tax rates must be set sufficiently high (i.e., at least 20%) to be effective and that SSB taxes alone may be insufficient to reduce energy intake enough to decrease population weight.

The most recent systematic review on the impact of SSB taxes was conducted by Bes-Rastrollo et al (2016). In this review, 24 articles published through August 2015 were identified. Of these articles, 17 were conducted in the United States; 3 were conducted in Australia; and 1 each was conducted in India, Ireland, South Africa, and the United Kingdom. SSB tax rates varied, but the majority of the studies (17 of 24) indicated that SSB taxes were negatively associated with body weight and obesity prevalence. The authors discussed that nonsignificant results were mostly found in studies with relatively low tax rates. The findings were consistent with the previous recommendation that at least a 20% tax rate should be implemented (Mytton et al. 2012).

2.3 Cost-Effectiveness of Sugar-Sweetened Beverage Taxes

A simulation model was conducted to estimate the cost and impact of a $0.01 per ounce SSB tax in the United States over a 10-year period (Gortmaker et al. 2015, Long et al. 2015). According to the study, the total cost of implementing the tax during the 10-year period was about $430 million, while the revenue generated from the tax was $12.5 billion. The model estimated that the cost per unit of BMI reduction was about $3.16 and that the tax would result in health care cost savings of $23.6 billion, a $55 health care cost-savings per every $1 spent. Thus, SSB taxes are considered a cost-effective intervention.

2.4 Summary and Recommendations

Based on existing evidence, SSB taxes may be an effective and cost-effective approach when used with other interventions, such as education and subsidies, to tackle the obesity epidemic. Nevertheless, it should be noted that almost all studies on the effectiveness of SSB taxes were limited to modeling techniques conducted in countries with high SSB consumption (except India). Studies on the effectiveness and cost-effectiveness of SSB taxes conducted in low-income countries and countries with low consumption of SSBs merit further study.

Further, the associations among childhood obesity, SSB consumption, and socioeconomic status varied by country. In developed countries, a negative correlation was found between socioeconomic status and obesity, while in less-developed countries, a positive correlation was identified (Wang and Lim 2012, Aizawa and Helble 2016). With respect to the relationship between SSB consumption and socioeconomic status in general, it was found that SSB consumption was negatively correlated with socioeconomic status (Wold 2009, Mazarello Paes et al. 2015). Nevertheless, in some countries, especially developing countries or countries in socioeconomic transition, a positive correlation was identified for SSB consumption and socioeconomic status (Han and Powell 2011, Ha et al. 2016, Wold 2009). Such different patterns of the relationships among obesity, SSB consumption, and SES strongly support the need for further research on the effect of SSB tax in developing countries.

The price elasticity of demand and substitution effect are important factors in the design of effective SSB tax policies. As the prices of SSBs rise due to taxation, the consumption of SSBs is expected to decrease. However, taxation rates need to be high enough to have a significant impact (Mytton et al. 2012). It should also be noted that the SSB tax is complicated because consumers have many food alternatives or substitutes if only one type of food is taxed. To reduce substitution with other unhealthy foods, the tax should be imposed on all kinds of SSB products, not only on carbonated drinks. In addition, taxes on a broad range of energy-dense products (i.e., those in high in fat and sodium), and fruit and vegetable subsidies for specific population groups may be considered when used with SSB taxes (WHO 2015).

Although SSB taxes are considered an attractive political option, common criticism for implementing SSB taxes is their regressive impact. Similar to other consumer taxes, the poor pay a greater proportion of their income in taxes than other segments of the population. Nevertheless, it should be noted that a SSB tax is also progressive and leads to a reduction in health inequality, given that the poorer segments consume more SSBs, have a higher prevalence of obesity, and are more sensitive to price changes; thus, they are more likely to have more benefits from such an intervention (Pomeranz 2013).

3. FOOD LABELING

Food labeling is a practical tool that can empower consumers to choose healthy diets. It is increasingly considered one of the more important components of multicomponent strategies to tackle obesity. Nutrition label formats can be classified into two categories: front-of-package labels, and back-of-package labels. At present, back-of-package labels are the most widely adopted format (European Food Information Council 2014). In addition, several symbols or logos, such as traffic lights, keyholes, hearts, and green checkmarks, have been developed to facilitate consumers' understanding of nutrition information. The traffic light and guideline daily amount (GDA) are among the most widely adopted formats (OECD 2014).

At present, many high-income countries, such as Australia, Canada, New Zealand, and the United States, mandate the display of nutrition information on pre-packed foods. According to a European Union regulation (OECD 2014), compulsory food labels had to be implemented by 2016. These labels, expressed as GDAs, indicate energy, fat, saturated fat, carbohydrates, sugars, proteins, and salt.

In light of the growing interest in nutrition labeling policy and regulation, numerous studies have been conducted to examine the effects of food labeling on consumers' understanding of food labeling schemes, food choices, eating habits, perceptions toward nutrition labeling, and calorie intake.

3.1 Effectiveness of Food Labeling

Several studies have been conducted on the impact of labeling on food selection and dietary intake. Numerous studies have focused on factors associated with the use of labeling and understanding of and attitudes toward food labeling. However, no systematic review nor meta-analysis examining the impact of food labeling on BMI or obesity prevalence exists, so systematic reviews and meta-analyses on the use, understanding, and impact of nutrition labeling on food selection and dietary intake are examined in this section.

Cowburn and Stockley (2005) conducted a systematic review on consumer understanding and use of nutrition labeling when making decisions about food selection. In their review, 103 studies from North America and Northern Europe were identified, and most were of moderate to poor quality. About one-third (28%) were conducted in real-world settings where the subjects actually made food purchase decisions. The review indicated that most consumers reported that they often or at least sometimes look at nutrition labels when purchasing food; women with higher income and education levels were more likely to look at nutrition labels. With respect to understanding nutrition labeling, the review found that consumers have difficulty understanding the information included on the label, especially when converting information from grams per 100 grams to grams per serving size and percent energy.

Compos et al. (2011) conducted a systematic review on the impact of labeling on consumer dietary habits. In addition, the prevalence of labeling use and consumer understanding of nutrition labeling were examined. The authors identified 120 studies from the United States (87 studies), Europe (13 studies), Canada (9 studies), Australia and New Zealand (4 studies), Norway (2 studies), Germany (1 study), Thailand (1 study), Trinidad and Tobago (1 study), and multicountry (2 studies). Of 65 studies that reported the prevalence of label use among consumers, self-reported label use was high, especially in New Zealand (82%), United States (75%), Canada (52%), and Europe (47%). People who were middle-aged, female, high-income, highly educated, and had healthier eating habits were more likely to report greater use of nutrition labeling.

While many of the studies found that consumers generally perceive nutrition labels to be useful, several others indicated that many consumers have difficulty understanding the information presented on the labels, especially for recommended daily amount, serving size, and percent daily values (Compos et al 2011). With regard to label format and content, some indicated that the use of graphics, such as traffic lights, helped increase consumers' understanding and that providing nutrition information using front-of-package labeling is more effective than back-of-package labeling. Inconclusive evidence was found with regard to the level of detail or complexity of information favored by consumers. In terms of nutrition information sought by consumers, most studies found that most consumers look for information on fat and energy content. When looking at the impact of nutrition labels on dietary habits, the association between the use of nutrition labels and a healthier diet was consistently found.

Cecchini and Warin (2016) conducted a systematic review and meta-analysis to examine the impact of food labeling on food choice and calorie intake. In their study, nine peer-reviewed, randomized control studies published in English or French between 2008 and 2015 were identified. All studies were conducted in high-income countries: Australia, Canada, France, Germany, the United Kingdom, and United States. For each study, the proportions of subjects that switched to healthier products and changed calorie intake following the implementation of food labeling were extracted. In addition, the comparison of three formats of food labeling schemes on food choices and food consumption were assessed: traffics lights, GDA, and others (e.g., front-of-package labels). The results showed that food labeling increased the proportion of people selecting healthier food choices by 17.95% (95% CI: 11.24%–24.66%). When comparing across labeling schemes, traffic light schemes were more effective than GDA and other schemes in increasing the selection of healthier food products. However, food labeling did not significantly reduce caloric intake. The author explained that increasing the selection of healthier food choices by substituting unhealthy foods (e.g., trans fats) with healthier options (e.g., polyunsaturated fats) did not necessarily lead to a difference in caloric intake. Most of

these studies were based on small sample sizes. A quality assessment of these studies was not conducted, but high heterogeneity was identified. Based on these limitations, the findings should be interpreted with caution. In addition, all were randomized conducted in a laboratory setting in high-income countries, so further studies conducted in real-world settings and in low- and middle-income countries are needed.

Mandle et al. (2015) conducted a narrative review of studies examining consumer use of and attitude toward nutrition labeling in countries outside of North America, Australia, New Zealand, and Europe; 27 studies conducted in 20 countries in Asia, Africa, Latin America, and the Middle East were identified. According to the review, education and socioeconomic status were positively associated with label use, and characteristics associated with label use are similar among the developing and developed countries. Most studies indicated that consumers prefer to have nutrition information labels on food packaging. Self-reported label use ranged from 40% to 70%. Common reasons for not using the nutrition labels were lack of interest, lack of time, and difficulties in interpreting the information on the label. In these studies, the percentage of consumers who reported understanding the labels were 26.2% in Malawi (Kasapila and Shaarani 2013), 24.4% in Trinidad and Tobago (Peters-Texeira and Badrie 2005, Kasapila and Shaarani 2013), 44% in Botswana (Themba and Tanjo 2013, Kasapila and Shaarani 2013), and 55.9% in the Republic of Korea (Kim and Kim 2009). When comparing the preferences for label reference units, several studies indicated that “per serving size” is preferable to servings listed as “per 100 grams” (Mahgoub et al. 2007, Kim and Kim 2009, Singla 2010, Gregori et al. 2013). With respect to labeling format, simple, clear labels that are easy to see and interpret, using symbols or pictures and avoiding complex technical information, are preferable.

3.2 Cost-Effectiveness of Food Labeling

Using the chronic disease prevention model developed by the Organisation for Economic Co-operation and Development (OECD) and WHO, Cecchini et al. (2010) examined the cost-effectiveness of nutrition labeling in Brazil, the PRC, Mexico, the Russian Federation, South Africa, and the United Kingdom. In the study, the cost per capita of implemented nutrition labeling ranged from $0.05 to $0.23. Based on the simulation, nutrition labeling was considered a cost-effective intervention in all studied countries after 20 years of implementation. In addition, after 50 years of implementation, it was found to be a cost-saving intervention in Brazil, the PRC, Mexico, and the Russian Federation.

Sacks et al. (2011) conducted a cost-effectiveness study of traffic-light nutrition labeling in Australia. With limited evidence on the effectiveness of traffic-light nutrition labeling on BMI, the study estimated the change in BMI and prevalence of obesity using energy intake. It was assumed that a 10% reduction in energy intake was achieved from nutrition labeling. According to the study, traffic-light labeling would result in a 1.3-kilogram reduction in mean weight (95% CI: 1.2–1.4). The cost of implementing traffic-light labeling (including cost to the food industry; cost of social marketing campaigns; and cost of implementing, administering, and enforcing legislation) was estimated at A$81 million (95% CI: 44.7–108.0). Total cost offset (i.e., future health care costs saved due to the reduction of obesity-related conditions as the result of labeling) was estimated at A$455 million. Thus, the study concluded that traffic-light nutrition labeling is a cost-saving intervention.

3.3 Summary and Recommendations

Existing evidence consistently shows that consumers perceive nutrition labels to be useful and that labeling has a significant impact on food selection. In addition, nutrition labeling is considered a cost-effective or even cost-saving intervention in many countries. Although there is limited evidence regarding its impact on calorie intake and BMI, current evidence suggests that food labeling may be a cost-effective measure when used in a multicomponent strategy to tackle the obesity epidemic. However, most related evidence is from studies that were conducted in high-income countries. Therefore, it is unclear as to what extent the findings can be applied to low- and middle-income countries, so further research is needed. The format and type of information content that balances label information completeness and complexity deserves further investigation as well. It should be noted that nutrition labeling alone may offer only limited benefits in tackling the obesity epidemic, so this should be implemented with other interventions, such as education, to increase consumer awareness and understanding of information placed on nutrition labels (Campos et al. 2011).

At present, food-labeling regulation varies across countries. The harmonization of food-labeling regulation would not only help protect consumers but also decrease trade barriers and costs. Several regions have begun working toward the harmonization of food labeling in their regions (Tee et al. 2002, OECD 2014), and several related organizations, including WHO, Food and Agriculture Organization, and World Trade Organization are encouraging the harmonization of food-labeling regulation (FAO 2007, Kasapila and Shaarani 2011, Ettinger 2014). Harmonization is, however, complex, requiring governments, food industries, and academia to work closely together.

4. MARKETING RESTRICTIONS ON UNHEALTHY FOOD

Current evidence shows that children and adolescents may be at high risk of exposure to unhealthy food marketing (Kelly et al. 2010, Adams et al. 2012, Zhenghua et al. 2015). Kelly et al. (2010) reviewed studies conducted in 13 countries in Asia, Western Europe, and North and South America from 2007 to 2008, indicating that food advertisements accounted for 11%–29% of all TV advertisements. In addition, foods high in undesirable nutrients or energy accounted for 53%–87% of all food advertisements. On average, it was estimated that children are exposed to five food advertisements per hour.

Unhealthy food and beverage advertisements may affect children's eating habits and be associated with increased childhood obesity (Cairns et al. 2009). In 2010, WHO released recommendations urging member states to restrict the marketing of unhealthy foods and beverages to children (WHO 2010). Since 2011, several countries, mostly developed, have tightened their regulations on the marketing of unhealthy foods and beverages to children (OECD 2014), but many still rely on industry self-regulation to reduce the exposure of unhealthy food advertisements to children.

4.1 Food Advertisement and Obesity Risks

There is no systematic review or meta-analysis on the effects that advertisements have on BMI and obesity. However, many have been conducted on the impact of exposure to unhealthy food and beverage advertisements on dietary intake and dietary behavior (Cairns et al. 2009, Mills et al. 2013, Boyland et al. 2016, Sadeghirad et al. 2016).

In this section, three recent meta-analyses examining the effects of food advertising on dietary intake, dietary preference, food-related behaviors, attitudes, and beliefs are identified.

A recent meta-analysis by Sadeghirad et al. (2016) examined the effects of unhealthy food and beverage marketing on dietary intake and preferences among children aged 2–18 years. It identified 29 randomized, controlled trials published through January 2015, 17 on dietary preference and 9 on dietary intake. All were conducted in high-income countries, Australia, Canada, the Netherlands, United Kingdom, and United States, and examined the impact of advertising delivered through television, movie commercials, advergames (i.e., electronic games to advertise a product), and branded logos. About half of these studies have a high risk of bias.

With regard to dietary intake, the study identified a significant increase in dietary intake (mean difference = 30.4 kilocalories, 95% CI: 2.9–5.79) among children exposed to unhealthy food advertisements during or shortly after the exposure. When looking at dietary preference, children exposed to unhealthy food and beverage advertisements are 1.1 times more likely to choose the advertised product (RR = 1.1, 95% CI: 1.0–1.2). Using GRADE methodology to assess the quality of evidence-synthesis from this meta-analysis, the quality of evidence on dietary preference is moderate to low, while the quality of evidence on dietary intake is moderate. The study also suggested that younger children may be more vulnerable to the influence of unhealthy food and beverage advertisements.

Mills et al. (2013) conducted a systematic review examining the impact of food and beverage advertisements on food- and beverage-related behavior, attitudes, and beliefs in the adult population. It included nine studies published between 1980 and 2012 and conducted in developed countries (i.e., France, the Netherlands, and United States). Almost all of the identified studies were randomized, controlled trials that involved small sample sizes and were of moderate to poor quality. Further, all focused on television advertisements. Due to the heterogeneity, a meta-analysis was not conducted. This review indicated inconclusive effects of food advertising on food-related behaviors, attitudes, and beliefs, and revealed that the impacts of advertising vary across gender, weight, and existing food psychology.

Boyland et al. (2016) conducted a systematic review and meta-analysis examining the impact of acute exposure to unhealthy food and beverage advertising on dietary intake in children and adults. Only experimental studies, which focused on the impact of exposure from television and the internet, were included in this review. Seven studies were used to estimate the impact of advertisements on adults, while 13 studies were used to estimate the impact on children. The results revealed that exposure to advertisements result in a significant increase in dietary consumption (standard mean difference 0.37: 95% CI: 0.09–0.65). High heterogeneity (I^2 = 98%) was found, so the evidence should be interpreted with caution. When looking at adults, no significant effect of advertisements on dietary intake was found, but acute exposure to unhealthy food advertisements significantly increases the dietary intake among children (standard mean difference 0.56: 95% CI: 0.18–0.94). It is also worth noting that the evidence from children varied widely, resulting in high heterogeneity (I^2 = 98%).

4.2 Effectiveness of Marketing Restrictions on Unhealthy Food

A few studies examining the impact of unhealthy food advertising restrictions on BMI and obesity were based on mathematical simulation methods (Haby et al. 2006, Magnus et al. 2009, Veerman et al. 2009, Cecchini et al. 2010). A mathematical simulation for children aged 6–12 years was conducted in the United States,

suggesting that by reducing to zero the exposure to television advertising of foods high in fat, sugar, and/or salt among children, the average BMI can be reduced by 0.38 kg/m^2 (Veerman et al. 2009). Similarly, a simulation model conducted in Brazil, the PRC, India, Mexico, the Russian Federation, South Africa, and the United Kingdom estimated that the regulation of food advertisements can reduce BMI by 0.03 to 0.78 kg/m^2 (Cecchini et al. 2010).

No systematic review or meta-analysis that examines the effects of unhealthy food advertising restrictions on BMI or obesity exists. Systematic reviews examining the effects of unhealthy food market restrictions on the level of exposure of children are identified below, however.

Chambers et al. (2015) conducted a systematic review to examine the effects of statutory regulations and self-regulation of unhealthy advertisements on children, and included 19 studies examining the effects of statutory regulation and 25 studies examining the effects of self-regulation. The study revealed that about 84% of the studies (16 of 19 studies) examining the effects of statutory regulation found that such regulation is effective. All of the studies examining the effects of self-regulation conducted by the food industry (7 studies) found that self-regulation is an effective method. On the other hand, about 60% of the studies (11 of 18 studies) conducted outside of the food industry found that self-regulation is not effective.

Similarly, a previous systematic review (Galbraith-Emami and Lobstein 2013) compared the changes in children's exposure to unhealthy advertisements after statutory regulation and self-regulation. The review found that high levels of exposure to unhealthy food advertisements still exist in several countries and revealed that studies sponsored by the food industry are more likely to indicate that self-regulation is effective in reducing the level of exposure to unhealthy food advertisements.

4.3 Cost-Effectiveness of Marketing Restrictions on Unhealthy Food

Using modeling techniques, the cost-effectiveness of banning unhealthy food and beverage television advertisements during children's peak viewing times was conducted in Australia (Magnus et al. 2009). An incremental cost-effectiveness ratio was estimated at A$3.70 per DALY. Using the threshold of A$50,000 per DALY, the interventions were considered very cost-effective.

Using the chronic disease prevention model, Cecchini et al. (2010) examined the cost-effectiveness of restrictions on marketing unhealthy foods to children in Brazil, the PRC, India, Mexico, the Russian Federation, South Africa, and United Kingdom. In the study, the cost per capita of implementing such an intervention ranged from less than $0.01 (in the PRC and India) to $0.30 (in the United Kingdom). Based on the simulation, after 20 years of implementation, restricting unhealthy food marketing to children is considered a cost-saving intervention in Brazil, and a cost-effective intervention in all of the other countries except India. In addition, after 50 years of implementation, it was found to be a cost-saving intervention in Brazil and the PRC, and it was cost-effective in all of the other countries.

4.4 Summary and Recommendations

Although there is limited evidence on the long-term impact of advertisements on adult body weight and obesity, current evidence has consistently found that unhealthy food and beverage advertisements may increase dietary intake and preferences for unhealthy food in children during or shortly after exposure to such advertisements. In addition, restrictions on unhealthy food advertisements were found to be cost-effective interventions in many settings. Thus, statutory regulations on unhealthy food advertisements may be regarded as a promising intervention in a multicomponent strategy that tackles obesity. Nevertheless, due to the limited evidence, the impact of government regulations on unhealthy food advertisements on BMI and obesity prevalence deserves further investigation. As most existing evidence focused on television advertising, the effects of food advertising delivered through other media, such as the internet, also warrant further investigation. High-quality evidence is needed to further understand the impact of food advertisements on adults, and more studies in less-developed countries are also needed.

5. SCHOOL-BASED INTERVENTIONS

Schools are considered a promising setting for obesity prevention and control among children and adolescents due to their organizational structure, which facilitates the development of interventions using multiprofessional and multicomponent approaches. In addition, children and adolescents spend a significant proportion of their time at school. Due to the increased interest in school-based interventions, numerous studies have been conducted to examine the effectiveness of such interventions. According to a review by WHO, among interventions aimed at tackling the obesity epidemic, the effectiveness of school-based interventions was mostly assessed (WHO 2009).

School-based interventions include several activities intended to create environments and cultures that support children eating healthier foods and being more active, such as nutrition education classes, physical education, activities that promote movement and exercise, and improvements in the nutritional quality of school food. Several school-based programs also involve other settings, such as homes and communities. Many also involve parental support to encourage children to be more active, spend less time watching television and playing video games, and eat more healthy foods.

5.1 Effectiveness of School-Based Interventions

To date, many systematic reviews and meta-analyses have been conducted to summarize the effectiveness of school-based interventions. Several meta-analyses showed inconclusive results in terms of the effectiveness of school-based interventions, which may be due to the differences in study selection criteria, intervention delivered (i.e., characteristics, duration, intensity, and components), and outcomes (e.g., BMI, obesity prevalence, skinfold thickness, waist circumference, physical activity, and dietary behavior). A large variation across these studies was found in several systematic reviews and meta-analyses. For example, one meta-analysis (Guerra et al. 2013) examined the effectiveness of school-based interventions focusing on physical activity, but the types of physical activity included were diverse—dance, games, recreational athletics, endurance and resistance training, and sports. In addition, the weekly amount of time spent on intervention activities ranged from 75 to 270 minutes, while the duration of the interventions ranged from 2 to 48 months.

Due to the limited number of good-quality studies, and high heterogeneity identified in many reviews (Campbell et al. 2001, Doak et al. 2006, Flodmark et al. 2006, Kropski et al. 2008, Li et al. 2008), the effectiveness of school-based interventions cannot be clearly concluded. Mixed results were identified from several reviews (Doak et al. 2006, Flodmark et al. 2006, Lissau 2007, Brown and Summerbell 2009). Some concluded that school-based interventions were less likely to be effective (Kanekar and Sharma 2008, Harris et al. 2009), while others mentioned that school-based interventions were effective (Katz et al. 2008, Gonzalez-Suarez et al. 2009, Silveira et al. 2011)

To summarize the effectiveness of school-based interventions, three reviews of the existing systematic reviews and meta-analyses are identified below. In addition, evidence from recent related systematic reviews and meta-analyses, including one conducted in low- and middle-income countries, is also reported.

Amini et al. (2015) looked at existing English systematic reviews and meta-analyses published between 2001 and 2011 that aimed to evaluate the effectiveness of school-based interventions. Included in this study were 8 studies (4 systematic reviews and 4 meta-analyses) with a total of 106 primary studies. It should be noted that most of the primary studies were conducted in Western countries, especially the United States. According to this review, only two studies examined the effects of single-component interventions, which were physical activity (Harris et al. 2009), and nutrition education (Silveira et al. 2011). The other studies examined multicomponent interventions. All eight studies reported the effectiveness on anthropometric outcomes.

In terms of body weight or BMI reductions, the authors found that the effectiveness of school-based interventions was inconclusive in three studies. Two studies indicated that school-based interventions are effective, and two studies indicated that they are not effective. All studies reported high heterogeneity, most were at risk of publication bias, and many did not adequately assess or report the quality of primary studies. Therefore, conclusions should be made with caution. With regard to the components of interventions, it was unclear whether multicomponent interventions were more effective in terms of anthropometric outcomes than single-component interventions. However, the authors recommended that multicomponent interventions targeting both dietary activity and physical activity be implemented because they also bring other health and social benefits. In terms of duration, the review found that duration was an important factor, but the optimal length for interventions remains unclear. The effectiveness of the intervention also differed across genders with inconclusive patterns. In addition, the authors suggested that the negative effects of interventions should be studied.

Khambalia et al. (2012) summarized the effectiveness of school-based interventions from 8 studies, 5 systematic reviews, and 3 meta-analyses, published from 1990 to 2010. Five of the eight reviews were of high quality, and all studies showed evidence of heterogeneity in terms of study design, intervention, and outcome. Although high heterogeneity was identified, the review suggested that some characteristics of school-based interventions may be effective. In fact, this review found that interventions combining diet and physical activity, delivered over the long term, and with family involvement are more likely to be effective in terms of reducing children's weight. However, several found that the effectiveness of interventions differed by gender. The authors stated the need for additional high-quality studies that focus on identified specific intervention characteristics that contributed to the effectiveness of the intervention.

Safron et al. (2011) identified and reviewed 17 studies (12 systematic reviews and 5 meta-analyses), involving 196 primary studies that examined the effectiveness of school-based interventions. The quality of the included reviews was moderate to high. Among the reviews that reported BMI as an outcome, significant BMI reductions were found, on average, in 36% of the studies per review. Nevertheless, the effectiveness of the interventions was either small or insignificant, possibly due to the fact that the program was conducted with the general population instead of at-risk individuals. With respect to obesity or overweight prevalence, about 36% of the studies per review indicated that the interventions were effective. In terms of changes in physical activity and dietary behavior, about 57% and 96% (respectively) of the studies per review indicated that the interventions were effective. Effectiveness varied by gender and age; some interventions were more effective in girls and younger children. According to this review, interventions focusing on the reduction of sedentary behavior, moderate-to-vigorous physical activity, and parental involvement are promising.

Recent systematic reviews and meta-analyses published since 2015 that examine the effectiveness of school-based interventions are summarized below.

Wang et al. (2013) conducted a systematic review and meta-analysis to examine the effectiveness of childhood obesity prevention programs that followed participants for at least 1 year. Studies were only conducted in high-income countries. According to this review, at least moderately strong evidence indicated that school-based interventions are effective. Specifically, high-quality evidence indicated that physical activity only delivered at school with home involvement is effective. The evidence also indicated that a combination of physical activity and dietary intervention delivered at school settings and with the involvement of home and community settings is effective. Moderate-quality evidence indicated that school-based interventions focusing on only diet or physical activity delivered at school-only settings are also effective. When comparing single and multiple settings, it was found that multiple settings, especially the combination of school and home, are more likely to be effective than school-only settings. It should also be noted that high heterogeneity was found in the review, so findings should be interpreted with caution.

Hung et al. (2015) conducted a meta-analysis to examine the effects of school-based interventions, including studies that reported BMI or skinfold thickness as outcome measures. It also aimed to examine the effectiveness of each component of school-based interventions and identified 27 studies published between 1982 and 2010 that were conducted in the United States (15), United Kingdom (3), Greece (2), Italy (1), Finland (1), the Russian Federation (1), Denmark (1), Chile (1), Switzerland (1), and Australia (1). The study indicated insignificant effects of school-based interventions on the reduction of BMI or skinfold thickness (SMD = 0.039, 95% CI: –0.013–0.092). High heterogeneity was also reported. When looking at subgroup analysis, a randomized, controlled trial design with only one program component (either physical activity or nutrition) can significantly reduce BMI (SMD = 0.168, 95% CI: 0.085 to 0.252) with no heterogeneity as compared to interventions with multiple components and a nonrandomized study. The study also revealed that the inclusion of a nutrition component with the existing component does not significantly increase the effectiveness of the school-based program. Furthermore, it was found that the duration of the intervention, age, and parental or specialist involvement does not have significant effects on BMI or skinfold outcomes.

With regard to the evidence in low- and middle-income countries, Verstraeten et al. (2012) conducted a systematic review to examine the impact of school-based activities in the primary prevention of obesity in children and adolescents. Of 25 studies conducted in lower- and middle-income countries identified, 4 focused on only dietary activity, 10 focused on only physical activity, and 11 focused on a combination of dietary and physical activity. The included studies were of low or moderate quality. Due to the high variation across studies, meta-analysis was not conducted. This review found that 82% of the studies (18 of 22) reported significant positive effects of school-based interventions. Only 12 studies examined the effects of school-based interventions on anthropometric outcomes, while the other studies targeted dietary behavior and physical activity outcomes. Of the 12 studies, 8 found that school-based interventions are effective in terms of BMI reduction. Seven studies focusing on the impact of school-based interventions in terms of the reduction of obesity prevalence were identified. Of the seven studies, three found that the interventions (combinations of dietary and physical activity) are effective.

Finally, Kong et al. (2016) conducted a systematic review and meta-analysis of school-based nutrition education in the PRC. The meta-analysis identified 17 studies, many of which were of poor quality. It indicated significant effects of intervention on obesity (OR = 0.73; 95% CI: 0.55–0.98). Due to the large variation across studies (I^2 =90%), the results should be interpreted with caution.

5.2 Cost-Effectiveness of School-Based Interventions

Cecchini et al. (2010) employed the chronic disease prevention model to examine the cost-effectiveness of several interventions, including school-based interventions, aimed at preventing obesity. The model was applied to seven countries (i.e., Brazil, the PRC, India, Mexico, the Russian Federation, South Africa, and the United Kingdom). The cost of implementing school-based interventions ranged from $0.51 to $1.41 (in 2005 $) per student. The effectiveness of school-based interventions was found to be modest; after 50 years of implementation, school-based interventions are still less likely to be cost-effective.

The cost-effectiveness of school-based interventions was also recently examined in the PRC by Meng et al. (2013). In their study, an economic evaluation alongside a clinical trial was conducted. In Beijing, nine schools were involved in the study. The schools were randomly assigned as follows: three schools to nutrition intervention, three schools to physical activity, and three schools to a combination of nutrition and physical activity. In the other five cities, six schools per city were randomly assigned (three schools to a combination of nutrition and physical activity and three schools to serve as controls). The costs per capita to implement nutrition interventions, physical activity interventions, and a combination of nutrition and physical activity interventions are $7.80, $7.70, and $26.80, respectively. The study found that school-based interventions are cost-effective, estimating that the cost per a 1 kg/m^2 reduction in BMI from combined interventions is about $120. It costs about $1,310 to avoid one overweight and obesity case.

5.3 Summary and Recommendations

Besides the popularity of school-based interventions and the availability of numerous studies on the effectiveness of school-based interventions, there is inconclusive evidence on the effectiveness of such interventions on anthropometric outcomes and obesity. Nevertheless, school-based interventions still have the potential to be a

component in multicomponent strategies to tackle obesity, as they may provide other health benefits as well as help children develop healthy lifestyles regarding eating and physical activity, and these healthy lifestyles may remain throughout their lives.

Many reviews indicated that multicomponent interventions (i.e., a combination of diet and physical activity) involving multiple settings (i.e., school and home) are more effective than single-component interventions delivered in a single setting. However, conflicting findings also exist. A limited number of studies were designed to identify active components or to compare the effectiveness of components; therefore, it is difficult to determine the components that contribute to the effectiveness of the interventions. It should be noted, however, that the effectiveness of the components and characteristics that contribute to the effectiveness of interventions need to be proven before widespread promotion of school-based interventions can be justified. More well-conducted studies are needed, especially to examine the effectiveness in lower- and middle-income countries, explore gender differences, and note the negative effects of interventions.

Although the number of studies on effectiveness is growing, the few studies on cost-effectiveness clearly show the need for further investigation. Finally, as more studies are conducted, more recent systematic reviews and meta-analyses are needed to summarize the findings.

6. CONCLUSIONS

Although only a small effect in terms of BMI reduction was identified, current evidence consistently shows that SSB taxes are an effective and cost-effective intervention to prevent obesity. In fact, it should be noted that, from a long-term public health perspective, this small effect may represent an important reduction of obesity at the population level.

With respect to nutrition labeling, the current evidence indicates that consumers perceive nutrition labels to be useful and that labeling has a significant impact on food selection. Although there is limited evidence on its impact on BMI and obesity prevalence, nutrition labeling is considered a cost-effective intervention in many settings.

Concerning market restrictions for unhealthy food advertisements, there is limited evidence on the impact of restricting unhealthy food advertising on BMI and obesity prevalence. Nevertheless, current evidence indicates that unhealthy food and beverage advertisements may increase dietary intake and the preference for unhealthy foods, especially in children. In addition, it was found that market restrictions on unhealthy food advertising is a cost-effective intervention in many settings.

Due to the limited number of good-quality studies and high variation across these studies, the effectiveness of school-based interventions in terms of BMI reduction and obesity prevalence was inconclusive. When looking at cost-effectiveness evidence, current evidence suggests that school-based interventions are less likely to be a cost-effective strategy. Despite this limitation, school-based interventions should still be recognized as an integral part of strategies to tackle the obesity epidemic. This is especially true for children, because such interventions may result in other health and social benefits. Nevertheless, high-quality studies examining the effectiveness of school-based interventions are needed, especially studies that examine the characteristics of the components contributing to the effectiveness of the interventions.

Although numerous studies were conducted to examine the effectiveness of interventions aimed at obesity prevention and control, studies focused on the cost-effectiveness of such interventions are lacking. Therefore, more evidence on the cost-effectiveness of interventions is needed. Nevertheless, the review of economic evaluations of obesity-related policies and interventions found that almost all of the interventions (25 of 27) are economically beneficial (McKinnon et al. 2016).

For both effectiveness and cost-effectiveness studies, most evidence comes from high-income countries, so evidence from low- and middle-income countries and areas are needed. High heterogeneity and the limited number of high-quality studies were commonly observed for several types of interventions. High-quality studies are needed to examine the effectiveness of nutrition labeling, market restrictions on unhealthy food advertisements, and school-based interventions on BMI or obesity. Such studies are vital to support evidence-based policies aimed at tackling the obesity epidemic. Further investigation is also needed to examine the adverse effects of interventions, such as the social stigmatization and psychosocial problems of the obese, that are caused by these interventions as well.

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