From: Veronica Le Nevez
To: Committee, Health (REPS); Impact & Engagement
Subject: RE: [SEC=OFFICIAL] Inquiry into diabetes - Invitation to give evidence at public hearing on 20 November 2023
Date: Friday, 15 December 2023 4:04:48 PM

OFFICIAL

Dear Kate,
Apologies for the delay in sending these through.

Here are the papers requested by the Committee when we appeared on 20 November.

- On the point of has SSB levy been shown to improve health outcomes
  - The attached paper by Rogers et al – showed that UK's since introduction of the UK's sugar levy, obesity prevalence reduced by 1.6% among year 6 girls, with greatest impact in those from the most deprived communities. No effect in boys and younger children.
  - Here is another one with similar finding from Mexico (girls had reduced overweight and obesity prevalence).
  - although in some evaluations there was no association of SSB tax to overweight and obesity, it could be because the levy level was too low (<5%), therefore limiting impact on consumer behaviour
- On junk food advertising
  - The attached Haynes paper is the one that quantified SSB advertising dwarfed health promotion advertising by government (almost 5:1)
  - This a Conversation article two more articles mentioned in it are worth highlighting
    - Self regulation by industry in Australia has NOT led to reduction in junk food advertising to children: https://academic.oup.com/jpubhealth/article/39/4/787/2966185?login=true
    - In countries with mandatory ban on junk food advertising saw decrease in junk food sales: https://pubmed.ncbi.nlm.nih.gov/29521031/
  - The attached (Taillie et al) shows how many different countries are making such decisions (some based on nutrient profiling models etc).

Have a enjoyable Christmas and new year break –

With best wishes,
Veronica

Veronica Le Nevez
Head of Impact and Engagement, Impact & Engagement

The George Institute for Global Health | AUSTRALIA

Level 18, International Towers 3, 300 Barangaroo Ave, Barangaroo NSW 2000 Australia
PO Box M201, Missenden Rd, NSW 2050 Australia

| **W** www.georgeinstitute.org.au
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Special Article

Governmental policies to reduce unhealthy food marketing to children

Lindsey Smith Taillie, Emily Busey, Fernanda Mediano Stoltze, and Francesca Renee Dillman Carpentier

Reducing children's exposure to food marketing is an important obesity prevention strategy. This narrative review describes current statutory regulations that restrict food marketing; reviews available evidence on the effects of these regulations; and compares policy design elements in Chile and the United Kingdom. Currently, 16 countries have statutory regulations on unhealthy food marketing to children. Restrictions on television advertising, primarily during children's programming, are most common. Schools are also a common setting for restrictions. Regulations on media such as cinema, mobile phone applications, print, packaging, and the internet are uncommon. Eleven evaluations of policies in 4 jurisdictions found small or no policy-related reductions in unhealthy food advertising, in part because marketing shifted to other programs or venues; however, not all policies have been evaluated. Compared with the United Kingdom, Chile restricts marketing on more products, across a wider range of media, using more marketing techniques. Future research should examine which elements of food marketing policy design are most effective at reducing children's exposure to unhealthy food marketing.

INTRODUCTION

Across the globe, food marketing to children is pervasive, and the vast majority of products most heavily marketed to young people—sugary breakfast cereals, soft drinks, candy, salty snacks, and fast foods—are calorie dense, nutrient poor, and high in added saturated fat and/or *trans* fat, sugar, or sodium (HFSS).[1–13] Marketing of unhealthy foods influences children's food and brand knowledge, preferences, requests, purchases, and eating behaviors.[1,9,14–17] As a result, public health scholars and advocates as well as leading global health agencies such as the World Health Organization (WHO) have recommended implementation of policies to restrict or eliminate unhealthy food marketing to children as a critical strategy for obesity prevention.[18,19]

Several regulatory approaches have emerged to reduce children's exposure to unhealthy food marketing.[1,14,19] First, and most commonly, food and beverage industry groups have voluntarily established national and international self-regulatory programs to encourage more-responsible advertising.[20,21] Comparatively few jurisdictions have enacted statutory policies to regulate HFSS food marketing to children, and some have co-regulatory environments with both industry and statutory regulations in place (or government-endorsed industry self-regulation).[22] Other jurisdictions have statutory policies that restrict the marketing of any commercial product to children, including but not limited to unhealthy foods and beverages.

A growing body of literature indicates that attempts at voluntary self-regulation by food, beverage, and

Affiliation: *L.S. Taillie*, *E. Busey*, and *F. Mediano Stoltze* are with the UNC Carolina Population Center, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA. L.S. Taillie is with the Department of Nutrition, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA. *F. Mediano Stoltze* and *F.R. Dillman* Carpentier are with the School of Media and Journalism, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA.

Correspondence: *F.R. Dillman Carpentier*, School of Media and Journalism, University of North Carolina at Chapel Hill, CB 3365, Chapel Hill, NC 27599, USA. Email: francesca@unc.edu.

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restaurant industries have not meaningfully reduced children's exposure to marketing for unhealthy products,[23] but less is known about the effects of governmental policies on the measures that regulations are designed to address (eg, marketing exposure). Evidence on governmental food marketing policies is timely and critical, considering that a number of countries, including Colombia[24] and Canada,[25] have proposed statutory regulations to protect children from unhealthy food marketing.

The overarching objective of this review is to provide researchers and policymakers with information on existing governmental regulations that restrict unhealthy food marketing to guide the development of future policy. Specifically, in accordance with the WHO's 2012 Framework for Implementing the Set of Recommendations on the Marketing of Foods and Non-alcoholic Beverages to Children (WHO 2012 food marketing policy framework),[26] which outlines the process, key components, and key outcomes of food marketing regulations, this review aims to describe existing statutory regulations that limit unhealthy food marketing to children; review available evidence for these regulations' effects on output and outcome indicators, and conduct an in-depth comparison between regulations in the United Kingdom and Chile, 2 jurisdictions with recent governmental food marketing policies in place, on key elements of food marketing policy design.

METHODS

To identify existing statutory policies on food marketing to children, the following were reviewed: (1) the World Cancer Research Fund International's NOURISHING database,[27] which provides a regularly updated overview of worldwide policy actions implemented to promote healthy diets and reduce overweight and obesity, including "restricting food advertising and other forms of commercial promotion;"[22] (2) the WHO Global Database on the Implementation of Nutrition Action;[28] (3) published surveys of policy actions on food advertising and food marketing;[21,29–32] and (4) systematic reviews examining initiatives to reduce food and beverage advertising to children.[23,33] From these sources, countries or jurisdictions with policies that are statutory in nature (ie, legally binding and mandatory for all companies); that have clear implementation guidelines; that were implemented by December 1, 2018; and that restrict unhealthy food and beverage marketing to children were identified. This includes regulations that specifically restrict unhealthy food marketing directed at children, regulations that restrict unhealthy food marketing (to all populations, including children), and regulations that restrict marketing of all commercial products (including but not limited to food products). The dimensions of statutory food marketing policies are outlined in Table S1 in the Supporting Information online. Laws focused only on specific products or single categories (eg, energy drinks or early childhood food and beverage products like formula or toddler milks) were excluded.

For each policy, the most primary documentation of the law available, as well as implementation guidelines, was obtained from government websites and primary and secondary legislation databases.[34–36] Each regulation was then categorized into 1 of 2 categories: regulations that specifically restrict unhealthy food marketing, and regulations that restrict all forms of commercial marketing to children (including but not limited to food). Next, descriptions of key policy specifications, as outlined in the WHO 2012 food marketing policy framework,[26] were extracted (Table 1[27,30,37–69]). These include the following: (1) which children receive protection (definition/age ranges of children protected by the law); (2) which foods and beverages are subject to the law and how this is determined (eg, by applying nutrient profile models[70] or restricting certain categories); (3) how exposure is limited (defining child-directed media, communications, or settings subject to the law and in/on what communication channels marketing activities are restricted, eg, television [TV], the internet, etc); and (4) how power of HFSS food marketing is limited (describing what, if any, restrictions are placed on marketing techniques used to appeal to or persuade children and in what communication channels these restrictions apply).

Information on policy monitoring and enforcement were not included because of difficulty finding sufficient information for a number of countries or policies.

To assess available evidence on the effects of identified statutory regulations, a search was conducted for English-language, peer-reviewed evaluations that examine changes before and after implementation of the regulation or differences in outputs or outcomes between populations who were exposed vs unexposed to the regulation. Policy outputs and outcomes were categorized according to the WHO 2012 food marketing policy framework.[26]

The following output indicators (ie, shorter-term effects) were examined: (1) exposure, or the reach, frequency, and media impact of the message (eg, frequency or proportion of advertisements for unhealthy foods; number of websites popular among children with links to commercials; presence in schools of branded materials; etc.); and (2) power, or the extent to which a message achieves its communications objective (eg, number of advertisements using child-attractive graphics or themes; number of food company websites with child-directed content; number of product

packages with messages or graphics designed to attract a child's attention; etc).

The following outcome indicators (ie, longer-term effects) were examined: (1) children's awareness, attitudes, beliefs, and preferences for food; (2) children's food consumption and dietary patterns (eg, a reduction in intake patterns characterized by high levels of added sugar, sodium, saturated or *trans* fats); and (3) children's weight status (eg, a reduction in the prevalence of overweight and obesity).

Evaluations cited in previous systematic reviews of this subject[23,33] were examined first, along with evaluations listed in the World Cancer Research Fund International's NOURISHING database.[27] These yielded 10 studies for inclusion.[7,71–79] Then, Web of Science and PubMed databases were searched for studies published between April 1, 2013, and December 12, 2018, as earlier studies would have been captured in previous systematic reviews that searched through March 2013[33] and April 2013[23] (see Appendix S1 in the Supporting Information online for search terms). This search returned a total of 987 unique results, of which only 4 met all criteria for inclusion.[73,74,76,80] Of these 4, only 1 study was not already captured in an audit of previous reviews and the NOURISHING database.[80] The final 11 papers were examined by 2 authors (L.S.T. and E.A.B.) for relevance and suitability.

Data were extracted by 1 author (E.B.), reviewed by another author (L.S.T.), and entered into tables adapted from those used by Galbraith-Emami and Lobstein,[23] with the addition of a column for evaluation strengths and limitations to summary findings table (Table 2[2,7,30,38–40,58,59,71–85] and Table 3[7,30,37–40,58,59,71–80]).

Finally, a more in-depth comparison was conducted between the food marketing regulations in Chile and the United Kingdom. These regulations were chosen because the Chilean Law on Nutritional Composition of Food[50] and Law on Food Advertising[52] and the UK Code of Broadcast Advertising[37] (British Committee of Advertising Practice [BCAP] Code) are both statutory regulations that are designed specifically to protect children from unhealthy food and beverage marketing, with the aim of preventing childhood obesity.[86–88] This is in contrast to other regulations that restrict all forms of commercial marketing to children, which are not focused on food and are not motivated by specific concerns about childhood obesity. These regulations also shared specific similarities that permitted a useful comparative case study: (1) they define unhealthy foods and beverages on the basis of a specified set of nutrient criteria applied across all product categories; (2) they have the similar age groups of interest; (3) they share similar definitions for identifying and targeting TV advertising in terms of audience composition; and (4) they are not limited to a single setting (eg, schools). The UK advertising industry's Code of Nonbroadcast Advertising and Direct & Promotional Marketing[67] (CAP Code), updated in 2017 with guidance on advertising food and soft drinks to children in non–broadcast media,[68] is also considered. This code extends the protections of the BCAP Code to online and other nonmedia forms of marketing. While the CAP Code is not a true statutory regulation, it is included for comparison because it is applied uniformly to all food and beverage companies, and it has a monitoring and enforcement system in place (more detail provided below, in section *Comparison of policies in Chile and the United Kingdom*). These countries' regulations and codes were compared alongside the aforementioned policy design criteria, including the definition of children protected, the foods included, the limitations on exposure and power, and the monitoring and enforcement mechanisms.

RESULTS

Statutory regulations. Sixteen countries were found to have statutory regulations on food marketing to children that met the study criteria (Table 1). Of these, 10 countries specifically restrict marketing of unhealthy food to children, while 6 countries restrict marketing of all commercial products to children, including but not limited to food. Regulations in 5 countries define the target child population as less than 18 years of age, while regulations in 7 countries use lower age cutoffs ranging from less than 12 years to less than 15 years. Regulations in the remaining 4 countries do not specify a target age group but only restrict marketing or advertising in school settings.

Television is the most frequently restricted medium (10 jurisdictions), with the most common approach being to prohibit advertising on children's channels or during children's programming, defined as broadcast programs with a child audience share exceeding a specified threshold or proportion (5 countries) and/or as programs or channels with content directed primarily at children (7 countries). Four countries utilize time-based scheduling restrictions (ie, times of day when children are likely to watch TV), but these vary greatly in timing and duration. In South Korea, for example, advertising for unhealthy foods is prohibited on TV from 5:00 PM to 7:00 PM (as well as during children's programming outside of those times), whereas Mexico prohibits TV advertising of unhealthy food to audiences of greater than 35% children from 2:30 PM to 7:30 PM on weekdays and from 7:00 AM to 7:30 PM on weekends. Chile is the only country to combine advertising restrictions on the basis of content (devoted children's

Table 1 **Overview and key features of statutory regulations that restrict food and beverage marketing to children[a,b]**

		Which foods to include/exclude			Exposure: communication channels and settings																Power: marketing techniques
		Criteria/model used	Items to which regulation apply																		
Jurisdiction (year implemented)	Definition of children	How is it determined which foods and beverages are included/excluded?	All foods, drinks	Select categories	How are regulated child-directed communications, media, advertising, or settings defined?	TV	Radio	Cinema	DVD/CD-ROM	Internet/online	Mobile	Interactive games	Print	Signs and outdoor	Direct marketing	Packaging	Point of Sale	Product placement	Sponsorships	School settings	Events/venues	How are marketing techniques of particular appeal to children restricted (applies to channels and settings at left marked with an asterisk)?
Regulations specific to food and beverage products																					
United Kingdom (broadcast media 2007[37]; non–broadcast code excluded here[c])	4–15 y	Nutrient Profile Model[38]: points for vegetable, fruit, nut, fiber, and protein content subtracted from points for energy, saturated fat, total sugar, and sodium content; > 4 total points for foods or > 1 point for beverages = "less healthy" (HFSS)	✓		Placement and audience: broadcasting during children's programs or when 120 Index is met (ie, proportion of viewers ages 4–15 y is ≥ 20% higher than in general population)	✓ *	✓ *															Ads for HFSS products that directly targeted children ages 4–12 y may not use licensed characters, celebrities popular with children, or promotional offers and may not make health claims
South Korea (2010)[39]	< 18 y	Thresholds set by the Korean Food and Drug Administration[39] for calorie, total sugar, saturated fat, and sodium content of children's preferred foods (thresholds differ for snack foods vs meal substitutes)		✓	Time and placement: TV broadcasting before, during, and after programs aired from 5:00 PM to 7:00 PM and during children's programming	✓ *	*			*												Advertisers prohibited from offering gratuitous incentives (eg, free toys) in ads for HFSS products on TV, radio, or the internet
Ireland (2005,[30] updated 2013[40])	< 18 y (stipulations for children < 13 y, < 15 y)	UK Nutrient Profiling Model[38]: points for vegetable, fruit, nut, fiber, and protein content subtracted from points for energy, saturated fat, total sugar, and sodium content; > 4 total points for foods or > 1 point for beverages = "less healthy" (HFSS); cheese products exempt	✓		Audience: programs broadcast to > 50% of audience < 18 y of age; or commercial communications targeting children < 15 y or < 13 y or broadcast to > 50% of audience in these age groups	✓[d] *	✓[d] *										✓	✓			HFSS food ads outside children's programs must not include current program characters, licensed characters, celebrities, or sports stars (if targeting children < 15 y); health/nutrition claims; or promotional offers (if targeting children < 13 y)
Mexico (2014[41])	< 13 y	Category-specific thresholds set for energy, sodium, saturated fat, total sugar, along with minimum amounts of components to encourage (categories include potato chips, sweetened drinks, confectionery)		✓	Time and audience: TV broadcasting from 14:30 to 19:30 on weekdays and from 7: 00 to 19:30 on weekends to > 35% of child audience; TV broadcasting during films rated A or AA	✓		✓														No restrictions specified
Ecuador (2014[42,43])	Not specified	Processed foods exceeding set thresholds for total fat, saturated fat, total sugar, and sodium[43]; beverages containing caffeine or noncaloric		✓	Setting: advertising in educational establishments															✓		No restrictions specified

(continued)

Table 1 **Continued**

		Which foods to include/exclude			Exposure: communication channels and settings																Power: marketing techniques
		Criteria/model used	Items to which regulation apply																		
Jurisdiction (year implemented)	Definition of children	How is it determined which foods and beverages are included/excluded?	All foods, drinks	Select categories	How are regulated child-directed communications, media, advertising, or settings defined?	TV	Radio	Cinema	DVD/CD-ROM	Internet/online	Mobile	Interactive games	Print	Signs and outdoor	Direct marketing	Packaging	Point of Sale	Product placement	Sponsorships	School settings	Events/venues	How are marketing techniques of particular appeal to children restricted (applies to channels and settings at left marked with an asterisk)?
		sweeteners or whose content is < 50% of the natural food characterized in its formulation																			
Poland (2015[44])	Not specified	Products not included in food groups permitted for sale in schools or that exceed thresholds for total sugar, total fat, or sodium density set by the Ministry of Health[45]		✓	Setting: advertising and promotions in units of the educational system															✓		No restrictions specified
Uruguay (2015[46])	Not specified	Products not included in the list of food and beverage groups recommended for sale in educational centers; packaged, processed foods exceeding set thresholds for energy, fats, saturated fats, *trans* fats, total sugar, and sodium[47]		✓	Setting: advertising in educational establishments															✓ *		Within school settings, prohibits use of logos on school materials or other objects (eg, shirts, caps, backpacks); distribution of free samples or prizes; and use of competitions or raffles
Taiwan (2016[48])	< 12 y	Thresholds set by Taiwan Food and Drug Administration[49] for sodium content per serving and for percentage of calories from fats, saturated fats, or free sugar	✓		Time and placement: TV broadcasting on children's channels from 17:00 to 21:00	✓ *																Regulated products may not offer free toys
Chile (2016[50,51] updated May 2018[52,53])	< 14 y	Thresholds set by the Chilean Ministry of Health for calorie, saturated fat, sugar, and sodium content in products containing added free sugars, sodium, or saturated fats	✓		Time, placement, audience, and setting: all TV broadcast from 6:00 to 22:00. Outside of these hours, TV broadcast on devoted children's channels; during programs targeting children; or when child audience is > 20% (except during sports, cultural, artistic, or charity events, if certain criteria are met). Also included are websites targeting children or those with child audience of > 20%; preschools primary and secondary schools	✓ *	*	✓ *	*	✓ *	*	*	*	*	*	*	*	*	*	✓ *	*	Prohibits, in any marketing for regulated products, use of the following: celebrities, characters, cartoons (including brand equity); toys; stickers; animations; children's music; people/animals that capture children's interest; fantastic statements about product or its effects; situations representing children's daily life; children's expressions or language; interactive contests, games, or applications; or "hooks" unrelated to the product itself

(continued)

Table 1 **Continued**

Jurisdiction (year implemented)	Definition of children	Which foods to include/exclude: How is it determined which foods and beverages are included/excluded?	Which foods to include/exclude: Criteria/model used	Which foods to include/exclude: Items to which regulation apply: All foods, drinks	Which foods to include/exclude: Items to which regulation apply: Select categories	Exposure: communication channels and settings: How are regulated child-directed communications, media, advertising, or settings defined?	TV	Radio	Cinema	DVD/CD-ROM	Internet/online	Mobile	Interactive games	Print	Signs and outdoor	Direct marketing	Packaging	Point of Sale	Product placement	Sponsorships	School settings	Events/venues	Power: marketing techniques: How are marketing techniques of particular appeal to children restricted (applies to channels and settings at left marked with an asterisk)?
Turkey (2011,[54] updated March 2018[55])	< 18 y	Ministry of Health places foods into red, orange, and green categories; red categories (high in fats, *trans* fatty acids, sodium, or sugars; eg, confectionery, chips, sodas) subject to restrictions; orange categories subject to restrictions if foods exceed category-specific thresholds for energy, total fat, saturated fat, total sugar, free sugar, nonsugar sweeteners (milk drinks only), or salt; green categories unrestricted[56,57]			✓	Placement: broadcasting before, during, and after children's programs	✓	✓																Advertisements for products in red or orange categories broadcast outside of children's programing must stream easily legible text at the bottom of the screen with warnings promoting a regular and balanced diet
Regulations that limit marketing for all commercial products																							
Quebec, Canada (1980,[58] updated guidance issued 2012[59])[e]	< 13 y	No nutrient profiling model used; regulation applies to all commercial products		✓		Time, placement, and audience (considers 3 criteria): (1) Whether product is intended for/appeals directly to children; (2) whether ad is designed to attract children's attention; and/or (3) whether timing and placement are such that children are exposed (> 15% of child audience)[58]	✓	✓	✓	✓	✓	✓	✓	✓[f]	✓	✓			✓	✓			No restrictions specified
Norway (1992,[60] additional guidance issued 1997[61])	< 18 y	No nutrient profiling model used; regulation applies to all commercial products		✓		Placement: any advertising broadcast before, during, or after children's TV programs; any advertising for products or services of particular interest to children or in a form that particularly appeals to children	✓ *	✓ *															Prohibits featuring popular people or figures from Norwegian TV or radio programs aimed at children or young adults
Hungary (2008[62])	< 18 y	No nutrient profiling model used; regulation applies to all commercial products		✓		Setting: advertising in child welfare and child protection institutions, kindergartens, primary and secondary schools, and their dormitories															✓		No restrictions specified
Sweden (2010[63])	< 12 y	No nutrient profiling model used— regulation applies to all commercial products		✓		Placement: broadcasts immediately before, during, and after programs aimed primarily at children	✓ *																Prohibits featuring in advertising persons or characters who play a prominent role in programs primarily aimed at children

(continued)

Table 1 **Continued**

		Which foods to include/exclude			Exposure: communication channels and settings																Power: marketing techniques
		Criteria/model used	Items to which regulation apply																		
Jurisdiction (year implemented)	Definition of children	How is it determined which foods and beverages are included/excluded?	All foods, drinks	Select categories	How are regulated child-directed communications, media, advertising, or settings defined?	TV	Radio	Cinema	DVD/CD-ROM	Internet/online	Mobile	Interactive games	Print	Signs and outdoor	Direct marketing	Packaging	Point of Sale	Product placement	Sponsorships	School settings	Events/venues	How are marketing techniques of particular appeal to children restricted (applies to channels and settings at left marked with an asterisk)?
Spain (2011[64])	< 15 y	No nutrient profiling model used; regulation applies to all commercial products	✓		Setting: advertising in public/private kindergarten or primary or secondary school settings															✓		No restrictions specified
Costa Rica (2012,[65] updated 2013[66])	Not specified	No nutrient profiling model used; regulation applies to all foods and beverages	✓		Setting: advertising in preschools and primary schools and secondary public educational centers or institutions attended by children															✓		No restrictions specified

Abbreviations and symbols: ad(s), advertisement(s); HFSS, high in saturated fat, salt, or sugar; POS, point of sale;

✓, indicates marketing activity restricted;

*, indicates technique restricted.

[a]See Table S1 in the Supporting Information online for descriptions of policy dimensions and definitions of the communication channels and settings used here.

[b]This table provides summary information about each regulation, on the basis of the available information, for the purposes of documenting existing policies and facilitating comparison between different policy approaches around the world. It presents information on policies implemented as of December 1, 2018, and does not include all existing policies related to food marketing, does not capture all nuances of different regulations, and does not describe detailed coverage for every type of marketing. Not included here are so-called coregulatory arrangements made between government bodies and industry groups; advertising restrictions that are not specifically intended to protect children; and countries that have taken steps to restrict unhealthy food advertising to children but have not yet published implementation guidelines (eg, Brazil, Peru). For more information about these policies and others not included here, see the World Cancer Fund International's NOURISHING database.[27]

[c]The United Kingdom also has a Code of Non-broadcast Advertising and Direct & Promotional Marketing[67,68] (CAP Code) that, as of 2017, applies restrictions on unhealthy food marketing to non–broadcast media, including print advertisements, posters, cinema commercials, internet/online ads, commercial emails, viral ads, advergames, in-game ads, text messages, direct mail, competitions, special offers, and sales promotions. The CAP Code was not included in this table because it is not truly statutory in nature, but instead is a form of self-regulation by the advertising industry. While the advertiser-funded Committee of Advertising Practice and Advertising Standards Authority writes and oversees, respectively, both the CAP and the BCAP Codes, the UK government's Office of Communications (Ofcom) is responsible in law for only the BCAP Code.

[d]In addition, no more than 25% of advertising sold by a broadcaster may advertise HFSS foods or drinks, and no more than 1 in 4 ads included in any advertising break may advertise HFSS foods or drinks.

[e]Quebec's Consumer Protection Act, though passed and implemented before the advent of the internet and other new media and communication channels, is applied to all media and formats used to distribute or broadcast commercial advertising.[58,69]

[f]Exception: Commercial advertising aimed at children is permitted in children's magazines if the magazine or insert containing the advertisement is intended for children; if the magazine or insert is offered for sale or is inserted in a publication offered for sale; and if the magazine or insert is published at least every 3 months.[59]

channels or programs targeting children), audience composition (> 20% child audience), and time, with broad scheduling restrictions extending from 6:00 AM to 10:00 PM, regardless of programming type or audience. Schools or educational institutions are the next most common setting for marketing restrictions (7 countries). All but one of these countries (Chile) regulate marketing only in schools and do not address any other communication channels or settings.[22] Restrictions on marketing via other forms of media, such as cinema, mobile, print, packaging, and the internet, are uncommon.

The types of foods and beverages covered also vary, as do the nutritional criteria used to identify unhealthy products subject to regulation. Jurisdictions with regulations that apply to all commercial products (Quebec [Canada], Norway, Hungary, Sweden, Spain, and Costa Rica) do not use nutritional criteria, since marketing for all foods is restricted. Of the 10 countries with regulations specific to food marketing, 10 employ a method of nutrient profiling to identify which products are subject to restrictions. Four countries apply a nutrient profile model to all foods and beverages (United Kingdom, Ireland [except cheese products], Taiwan, and Chile), while 6 countries apply a nutrient profile model only to specific food and beverage categories (South Korea, Mexico, Ecuador, Poland, Uruguay, and Turkey). Turkey and Poland are unique in that they apply a nutrient profile model to certain food and beverage categories to identify specific products subject to marketing restrictions, while other categories face marketing restrictions for all products within the category, regardless of nutrient profile. Eight countries include thresholds for saturated fat content, while only 2 include limits on *trans* fats. Regarding sugar, 1 country includes limits on free sugar only; 7 include limits on total sugar only, and 2 (Chile and Turkey) include limits on both free sugar and total sugar. Only Turkey uses thresholds for nonsugar sweeteners, and this applies only to milk drinks. All 10 countries include limits on sodium content, and 7 countries include limits on energy (calories). Three countries use nutrient profile models that account for content of beneficial nutrients or ingredients: the UK model (also used in Ireland) uses a scoring approach in which points for beneficial nutrients or ingredients (ie, vegetable, fruit, nut, fiber, and protein content) are subtracted from points accrued from nutrients to limit (energy, saturated fat, total sugar, and sodium content),[38] while Mexico's regulation has set thresholds for "nutrients to encourage".

With regard to power, or the types of marketing techniques addressed, most commonly restricted were the use of free gifts and toys, celebrities, and licensed or other types of characters. Restrictions on promotions/promotional offers and health/nutrition claims were less common. Seven of the 16 policies specified no limits to the types of techniques or appeals permitted.

Evaluation studies. Eleven studies evaluating the effects of these statutory regulations were identified for Ireland,[77] South Korea,[75,76] the United Kingdom,[71–74] and Quebec, Canada[7,78–80] (Table 2). These studies focused primarily on the prevalence and proportion of HFSS food advertising on TV by examining either changes in these measures following implementation of regulations[71,74,75] or by comparing the measures between jurisdictions with and without restrictions (ie, groups more or less likely to be exposed to the effects of the regulation).[7,77,79,80] Three studies examined children's estimated exposure to HFSS food advertising on TV.[72,75,77] Three studies analyzed the use of child-directed marketing techniques on TV[77,79] or online.[80] Only 2 studies examined changes in household purchase behavior,[73,78] and 2 examined changes in industry advertising expenditures[73] or budgets.[75] No studies examined changes in individual awareness, attitudes, beliefs, or preferences, and only 1 examined changes in food intake, but these changes were not linked to changes in food marketing exposure.[78] No studies examined changes in weight status or other health outcomes. All studies were observational in nature and thus could not evaluate causal effects of regulations.

In general, findings were mixed as to whether the prevalence of HFSS food advertising decreased after the regulation (Table 3). In some cases, apparent decreases were accompanied by other changes in HFSS food marketing. For example, a 2012 evaluation in South Korea comparing TV broadcasts recorded for 1 month each in 2009 (preimplementation of advertising restrictions) and 2010 (postimplementation) found an 81% drop in the number of HFSS food ads placed during regulated children's prime time hours, an 82% reduction in children's gross rating points (GRPs, a proportion of audience reached) for HFSS food ads during regulated hours, and a 50% reduction in children's GRPs for HFSS food ads during other times.[75] However, a 2013 study in South Korea that surveyed HFSS and non-HFSS food companies to learn about changes in company marketing practices postimplementation found that more HFSS food companies introduced online, mobile, and social marketing than did non-HFSS food companies and found some evidence of product reformulation and reductions in package sizes among the latter.[76]

Evaluations of Quebec's regulation banning all commercial marketing to children showed mixed results for food advertising.[7,78–80] One content analysis comparing viewing diaries of English- and

Table 2 **Peer-reviewed studies evaluating statutory regulation of food and beverage marketing to children**

Reference	Design and objectives	Data sources	Sample	Media assessed	Coding	Output and outcome indicators
United Kingdom (Code of Broadcast Advertising [BCAP Code[37]]; phased implementation: April 2007, January 2008, January 2009)						
Boyland et al (2011)[71]	Design: cross-sectional survey Objectives: investigate extent and balance of food advertising for core and noncore foods and pattern variations across peak and nonpeak children's viewing times, channel types, program types, and broadcast month	Authors' survey: TV transmissions (6:00–22:00 recorded 1 weekday and 1 weekend day per month, January–December 2008)	N/A	TV: 5233.5 h (147 672 ads) recorded from 14 UK commercial stations with greatest viewing shares for children ages 4–15 y	Ads: channel, channel type, and program category; month of broadcast; time of broadcast (peak/nonpeak children's viewing); product type Foods: 29 categories assigned to core, noncore, or miscellaneous	Output (exposure): • Number of ads featuring core, noncore, and miscellaneous foods
Adams et al (2012)[72]	Design: repeated cross-sectional survey (pre-/postimplementation) Objectives: examine (1) restrictions' impact on relative exposure to HFSS food ads among all TV viewers and children; and (2) adherence to restrictions	Commercial broadcast data (6 mo pre-/postregulation): 1 wk in October 2006, 1 wk in July 2009	N/A	TV: 1 036 953 ads from all 288 channels broadcast in Tyne Tees region; 1 672 417 TV advertising PMVs for viewers aged $\geq$ 4 y, including 190 955 PMVs for children ages 4–15 y	Foods: HFSS status per UK FSA Nutrient Profiling Model[38]	Outputs (exposure): • Exposure to HFSS food ads (measured as PMVs) • Adherence to restrictions (measured as PMVs for HFSS products during restricted broadcasting times)
Silva et al (2015)[73]	Design: repeated cross-sectional survey Objective: quantify regulations' impact on household expenditures during periods of no regulation, voluntary self-regulation, and co-regulation	UK Living Costs and Food Survey[81]: Commercial advertising expenditure data (per capita quarterly household food and drink expenditures and advertising expenditures, April 2001–December 2009)	6000 UK households	HFSS food advertising in press, cinema, radio, outdoor, TV, direct mail, and the internet	Advertised foods: aggregated into categories of fruits and vegetables; HFSS foods; HFSS drinks; or others Advertising expenditures: media (press, cinema, radio, outdoor, TV, direct mail, the internet)	Outcomes: • Household HFSS food and drink expenditures • Industry advertising expenditures
Whalen et al (2017)[74]	Design: repeated cross-sectional survey Objective: compare nutritional quality of food advertising on UK TV in 2008 and 2010 (mid-/postimplementation)	Authors' survey: TV transmissions (6:00-22:00 recorded 1 weekday and 1 weekend day during February, April, June, August, October, and December 2010)	N/A	TV: 1931.5 h (56 162 ads) recorded from 13 UK commercial stations with greatest viewing shares for children ages 4–15 y and top 5 channels watched in previous week by 5- to 16-year-olds; compared with similar 2008 data from Boyland et al (2011)[71] (5233.5 h of recorded TV; 147 672 ads)	Ads: channel, channel type, program category, month and time of day of broadcast, and product advertised (eg, food/beverage, toys) Foods: 29 categories assigned to core, noncore, or miscellaneous	Outputs (exposure): • Food and beverage advertising prevalence (overall, during peak child viewing times, and by channel type) • Proportion of food advertising for core, noncore, and miscellaneous foods (overall and by channel type) • Proportion of food commercials broadcast by product category

(continued)

Table 2 **Continued**

Reference	Design and objectives	Data sources	Sample	Media assessed	Coding	Output and outcome indicators
South Korea (Special Act on Safety Management of Children's Dietary Life,[39] implemented September 2010)						
Kim et al (2012)[75]	Design: repeated cross-sectional survey Objectives: examine impact of regulation on food companies' TV advertising practices and changes in children's exposure to TV ads for EDNP foods	Commercial data: TV transmissions, advertising budget, and audience ratings (24 h/d during January, April, July, and October of 2009 and 2010)	N/A	TV: 9259 EDNP food and beverage ads recorded from 4 terrestrial channels and 1 cable channel in South Korea	Foods: EDNP status per Korea Food and Drug Administration guidelines[39] Broadcast period: regulated (5:00–7:00 PM) vs nonregulated	Outputs (exposure): • Number of ad placements • Exposure to EDNP food ads (measured in gross rating points or GRPs for ads that reached children aged 4–18 y) Outcome: • Total TV advertising budget
Lee et al (2013)[76]	Design: cross-sectional survey Objective: examine postimplementation changes in food companies' marketing mix	Authors' survey: Online questionnaire (July 12–August 4, 2011)	63 questionnaires completed by 32 EDNP and 31 non-EDNP food and beverage company representatives	All media ("4 Ps" of marketing mix: product, price, place, promotion)	Companies: EDNP vs non-EDNP (classified as EDNP if company produced any products in EDNP categories, per Korean national guidelines)	Outputs (exposure, power): • Changes in company strategies or activities within "4 Ps" of marketing mix
Ireland (Children's Advertising Code, implemented 2005;[30] superseded by BAI Children's Commercial Communications Code,[40] implemented 2013)						
Tatlow-Golden et al (2016)[77]	Design: cross-sectional content analysis Objective: identify (1) extent and HFSS nature of children's advertised diet on island of Ireland; (2) differences in HFSS food advertising between 2 jurisdictions on island of Ireland; and (3) persuasive techniques used to promote HFSS and healthier foods at times and on channels when young children are most likely to be viewing	Authors' survey: TV transmissions (15:30–20:59 on Mondays and Thursdays and 9:30–10:59 and 18:30–21:59 on Saturdays and Sundays, for 5 consecutive weeks, from October 8 to November 11, 2012)	N/A	TV: 210 h (7698 ads) recorded from 7 channels in 2 jurisdictions (Republic of Ireland and Northern Ireland) with highest viewership among children ages 4–6 y	Foods: (1) HFSS status per UK FSA Nutrient Profiling Model[38]; (2) marketing permitted/not permitted per WHO Regional Office for Europe Nutrient Profile Model[82]; (3) categorization to 13 food groups; (4) comparison of food groups with UK Eatwell Plate[83] recommendations Ads: food type (37 codes) and marketing techniques (76 codes; eg, ad features, settings, characters, and persuasive and informational appeals)	Outputs (exposure): • Prevalence of TV food advertising (overall, by jurisdiction, by channel, and per hour) • Proportion of TV food ads from each food group, healthy vs less-healthy • Estimated children's exposure to TV food ads in each jurisdiction (overall and for less-healthy foods) • Percentage of food groups represented in advertised diet vs recommended representation in Eatwell Plate[83] Output (power): • Frequencies of use of advertising techniques (overall and by HFSS status)

(continued)

Table 2 **Continued**

Reference	Design and objectives	Data sources	Sample	Media assessed	Coding	Output and outcome indicators
Quebec, Canada (Consumer Protection Act[58], implemented 1980, updated guidance issued 2012[59])						
Dhar & Baylis (2011)[78]	Design: natural experiment following implementation Objective: examine whether advertising ban affected fast food consumption	Statistics Canada FOODEX[84] and Famex[85] surveys (1984, 1986, 1990, 1992)	9177 households (5024 in Ontario; 4153 in Quebec)	N/A	N/A	Outcomes: • Fast food purchasing propensity • Fast food expenditures • Fast food calories consumed
Potvin Kent et al (2011)[79]	Design: cross-sectional content analysis Objective: compare TV food marketing exposure among Quebec French- and English-speaking children and Ontario English-speaking children	Authors' survey: • 7-d TV viewing diaries to establish children's preferred programs • TV transmissions (6:00–24:00, March 26–April 1, 2009)	428 children aged 10–12 y (1 aged 13 y) from 2 metropolitan regions in Canada (225 English-speaking children in Ontario, 156 French-speaking children in Quebec, and 47 English-speaking children in Quebec)	TV: 90 h of children's preferred programs recorded from 32 Canadian stations; 1511 ads (387 food and beverage ads)	Promotions: ads, contests, or sponsorships Ads: day and time; type of program and station; type and length of promotion; product type; promotional techniques; and target audience	Outputs (exposure, power): • Number of ads, contests, and sponsorships by food and beverage product category • Cumulative frequency and percentages of food and beverage promotions, overall and by food and beverage category
Potvin Kent et al (2012)[7]	Design: cross-sectional content analysis Objective: compare nutritional quality of foods advertised during children's preferred TV viewing in Ontario and Quebec	Authors' survey: • Children's viewing diaries and TV transmissions from previous study[79] • Nutritional content from company websites and informants, product labels, Canadian Nutrient File, and USDA National Nutrient Database	428 children aged 10–12 y (1 aged 13 y) from Ontario and Quebec (same sample used in previous study[77])	TV: 90 h of children's preferred programs recorded from 32 Canadian stations; 1809 TV ads (449 food and beverage ads)	Foods: nutrition profiling (using nutritional content per 100 g for 427 products) based on the following: (1) criteria[2] for high fat, high saturated fat, high sugar, high sodium, low fiber, high fat or high sugar, and high fat, sugar, or sodium; and (2) healthy vs less healthy per UK Nutrient Profiling Model[38]	Outputs (exposure): • Nutrient density of advertised products • Proportion of advertised products classified as high fat, high saturated fat, high sugar, high sodium, low fiber, high fat or high sugar, and high fat, sugar, or sodium • Proportion of advertised products classified as healthy vs less healthy

(continued)

Table 2 **Continued**

Reference	Design and objectives	Data sources	Sample	Media assessed	Coding	Output and outcome indicators
Potvin Kent et al (2013)[80]	Design: cross-sectional content analysis Objective: assess influence of Quebec's Consumer Protection Act and industry self-regulations in Ontario on food manufacturer and restaurant websites in Canada	Authors' survey: • Children's viewing diaries and TV transmissions from previous study[79] • Canadian food manufacturer and restaurant websites (3-wk period in spring 2010)	428 children aged 10–12 y (1 aged 13 y) from Ontario and Quebec (same sample used in previous study[77])	Websites: 147 Canadian websites corresponding to food and beverage products advertised during children's preferred TV programs in Ontario and Quebec (excluded if unlikely to include child content or if product/company did not have a Canadian website)	Websites: English or French language; membership in CAI industry self-regulation Content: marketing features; links to other pages or websites; games and activities; child protection features; or healthy lifestyle messages	Outputs (power): • Number of websites with child-directed content • Number and percentage of websites with marketing features, child protection features, games and activities, and healthy lifestyle messages

Abbreviations: ad(s), advertisement(s); BAI, Broadcasting Authority of Ireland; CAI, Canadian Children's Food and Beverage Advertising Initiative; EDNP, energy-dense, nutrient-poor; GRP, gross rating point; HFSS, high in saturated fat, salt, or sugar; N/A, not applicable; PMVs, person-minute-views; USDA, US Department of Agriculture; WHO, World Health Organization.

French-speaking children aged 10 to 12 years in Quebec and Ontario found that the French-speaking Quebec group (expected to be most affected by the law) and the English-speaking Quebec and Ontario groups saw similar amounts of food advertising on TV (4–5 food ads per hour). There was, however, a higher prevalence of child-targeted food advertisements and child-directed appeal techniques (ie, use of fun theme or media characters and celebrities) in the sample viewed by the 2 English-speaking groups than in the sample viewed by the French-speaking Quebec group.[79] A second evaluation using the same TV sample found that the Quebec French group saw slightly fewer ads for "less healthy" foods and beverages (as described in the UK Nutrient Profile Model[38]) than the 2 English-speaking groups, yet the overall prevalence of ads for "less healthy" products was still high for all groups (60.6% of food and beverage ads seen by Quebec French vs 68.9% seen by Quebec English and 68.3% seen by Ontario English).[7] A third evaluation of Canadian French- and English-language food and restaurant websites found no significant differences between the English and French websites in the proportion of sites with child-directed content or in the frequencies or average number of various marketing features used, including advergames, spokescharacters, and branded virtual activities.[80] Finally, an evaluation of food expenditure survey data found households most likely to be affected by the Quebec regulation (ie, French-speaking households with children) had a 13% reduction in likelihood of purchasing fast food compared with households less likely to be affected by the regulation (ie, English-speaking households in Quebec and neighboring Ontario),[78] although the study did not include any data on these households' actual HFSS food advertising exposure.

In the United Kingdom, relative exposure to HFSS food advertisements did not change greatly following introduction of the BCAP Code. A cross-sectional survey examining TV advertising in 2008, midimplementation of broadcast restrictions, found that over half of the food and beverage ads surveyed from TV channels most popular with children were for noncore, less healthy foods.[71] A follow-up study comparing a similar 2010 TV sample with the 2008 sample found that the proportion of food advertisements for noncore products declined only slightly from 2008 to 2010 (−2.2%).[74] This proportion increased, however, during children's peak viewing times overall (+0.5%), on music channels (+11.6%), and on a sports channel (+7.7%). Similarly, another study that compared TV ads broadcast pre- and postimplementation found that children's exposure to advertisements for HFSS food products did not change after the regulation.[72] A 2015 study that

Table 3 **Key findings, strengths, and weaknesses of peer-reviewed papers evaluating statutory regulations to limit advertising of food and beverage products to children**

Reference	Key findings	Author conclusions	Strengths and limitations
United Kingdom (Code of Broadcast Advertising [BCAP Code[37]]; phased implementation: April 2007, January 2008, January 2009)			
Boyland et al (2011)[71]	Across the whole sample, ads for noncore foods appeared at a mean rate of 2.0 ads/h (maximum, 7.4), ads for core foods at 0.7 ads/h (maximum, 4.3), and ads for miscellaneous foods at 0.9 ads/h (maximum, 10.2). There were significantly more ads for noncore foods across all recorded samples (mean, 30.4 ads; 56%) than for miscellaneous (mean 14.8 ads; 25.9%) or core foods (mean, 10.4 ads; 18.1%) ($P < 0.001$ for all). The sports channel broadcast the greatest proportion of ads for noncore foods (78.3%), which was significantly greater than that on children's (59.8%), music (51.8%), or family channels (50.4%) ($P < 0.001$). Of the 10 most-advertised food products, 6 were noncore foods (fast food, unhealthy breakfast cereals, chocolate/confectionery, HFSS spreads, alcohol, and snack foods); only 1 was a core food (low-fat dairy items).	"Despite regulation, children in the UK are exposed to more TV advertising for unhealthy than healthy food items, even at peak children's viewing times. There remains scope to strengthen the rules regarding advertising of HFSS foods around programing popular with children and adults alike, where current regulations do not apply. Ongoing, systematic monitoring is essential for evaluation of the effectiveness of regulations designed to reduce children's exposure to HFSS food advertising on television in the UK."	Strengths: • Large sample covered major holidays and all seasons, examined relatively large number of TV channels • Examined differences in ad placement by channel type, programing type, and broadcast month Limitations: • Products were not categorized according to the Nutrient Profile Model used in the UK regulation; rather, used core (foods/drinks required to meet nutrient requirements), noncore (foods/drinks that provide nutrients and/or energy in excess), and miscellaneous foods • Did not examine ads aired between 22:00 and 06:00 • Outcome measured only number of ads, not viewers' exposure • Only examined changes in TV advertising—didn't capture any changes in HFSS food marketing or advertising via other channels/strategies
Adams et al (2012)[72]	Exposure (measured in PMVs) of children aged 4–15 y, week 2 (2009, postimplementation) vs week 1 (2006, preimplementation): • Lower odds of ad PMV being for food (OR = 0.85; 99%CI, 0.82–0.89) • No change in odds of ad PMV being for HFSS food (OR = 1.05; 99%CI, 0.99–1.12) • Greater odd s of food ad PMV being for HFSS food (OR = 1.25; 99% CI, 1.15–1.37) In 2009, after full implementation of scheduling restrictions: • 60.4% of TV food advertising seen by all viewers aged ≥4 y advertised HFSS foods, vs 38.6% 6 mo preimplementation. • 55.7% of TV food advertising seen by children (4–15y) advertised HFSS foods, vs 43.2% 6 mo preimplementation. Adherence to restrictions was nearly universal: of 68 545 PMVs among child viewers in study week 2 (2009) that were subject to the restrictions, 8 (0.01%) were for HFSS food products.	"Despite good adherence to the restrictions, they did not change relative exposure of children to HFSS advertising and were associated with an increase in relative exposure of all viewers to HFSS advertising. Stronger restrictions targeting a wider range of advertisements are necessary to reduce exposure of children to marketing of less healthful foods."	Strengths: • Use of PMVs offers a more accurate measure of exposure than gross rating points, since it considers different ad lengths and number of individuals watching • Sampled all ads on all channels (within study weeks and region) Limitations: • Measured short-term effects (6 mo after full implementation of broadcast restrictions) • Sampled data from different months pre and postimplementation (October in 2006 and July in 2009), likely capturing seasonal differences in advertising • Majority of nutritional information was collected from manufacturers in 2009, which could affect proportion of foods classified as HFSS in week 1 (2006) • Authors imputed estimated nutritional data for ≈ 50% of food ads; may have reduced accuracy of results and estimated adherence, owing to exclusion of imputed products from that analysis • Secondary broadcast data provided access to group-level data only; authors were not able to assess effects on individual-level exposure • Only examined changes in TV advertising; didn't capture any changes in HFSS food marketing or advertising via other channels/strategies

(continued)

Table 3 **Continued**

Reference	Key findings	Author conclusions	Strengths and limitations
Silva et al (2015)[73]	From 2001 to 2009, TV HFSS food advertising expenditures accounted for the majority, though a decreasing share, of HFSS food advertising expenditures. Press, cinema, and internet advertising expenditures had increasing trends. Self-regulation did not lead to significant changes in total or TV HFSS food advertising expenditures. Co-regulation led to a 9.7% reduction in total advertising (− £11.4 million, $P < 0.01$), driven by a 19.4% decrease in TV HFSS food advertising expenditures ($P < 0.01$), which was partially offset by increased non-TV advertising. 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 spent significantly less per capita/quarter on HFSS drinks under self-regulation, but significantly more on HFSS drinks under subsequent co-regulation ($P < 0.01$ for both).	". . .While co-regulation has been effective at reducing HFSS TV advertising expenditures, it has led to advertising reallocation from TV to non-TV media. In contrast, self-regulation does not appear to affect HFSS advertising expenditures.. . .Changes in child-directed food advertising regulations significantly impacted the expenditure of households with children on healthy and unhealthy food.. . .Advertising regulations may have had a bigger impact on households with children compared to those without children, though regulations may have spillover effects to households without children, at least in terms of expenditures of HFSS drinks."	Strengths: • Long sample period included periods of industry self-regulation alone and subsequent co-regulation (self-regulation plus statutory broadcast regulations) • Examined downstream changes in household demand for HFSS products • Examined advertiser spending across different media, capturing changes in overall marketing practices in response to broadcast-only restrictions • Used models to control for seasonality and economic growth in order to isolate regulation effects from secular trends Limitations: • Relied on expenditure data for food and drink consumed at home only • Household expenditures self-reported on a weekly basis, allowing for possibility of misreporting
Whalen et al (2017)[74]	The proportion of ads broadcast for foods decreased 4.3% on children's channels but increased across all other channel types (+ 0.3% on family channels, +3.0% on music channels, and + 4.3% on the sports channel). The proportion food advertising for noncore foods decreased 8.6% on children's channels (to 51.2% in 2010) and 30.1% on the sports channel (to 48.2%) but increased on family channels (+ 3.6%, to 54.0% in 2010) and music channels (+ 7.6%, to 59.4%). CiTV (a British free-to-air children's channel) broadcast the largest proportion of noncore commercials of any channel surveyed (68.8%). The proportion of food advertising for noncore foods was higher during peak vs nonpeak children's viewing times (+ 0.5%), especially on music channels (+ 11.6%) and the sports channel (+7.7%). Seasonal variation was indicated by an increase in the proportion of food advertising for noncore foods from June (46.9%) to August (64.3%), when UK schools close for summer. This difference was greater on dedicated children's channels, on which the proportion of food advertising for noncore foods climbed from 32.0% in June to 62.0% in August. These seasonal differences were more pronounced in 2010 than in 2008.	". . .Despite statutory regulation, frequency and balance of food commercials (core, noncore and miscellaneous) remained relatively static over the 2 yr. Children are still exposed to high amounts of unhealthy food advertising on television. Continued monitoring of television food advertising remains crucial and policymakers should examine the comparative efficacy of other restrictions."	Strengths: • Longitudinal comparison with similar baseline data[71] • Surveyed TV programing during peak children's viewing times rather than only on dedicated children's channels Limitations: • Provided descriptive statistics only (did not test for statistical significance) • Only examined changes in TV advertising; didn't capture any changes in HFSS food marketing or advertising via other channels/strategies

(continued)

Table 3 **Continued**

Reference	Key findings	Author conclusions	Strengths and limitations
South Korea (Special Act on Safety Management of Children's Dietary Life Safety Management,[39] implemented September 2010)			
Kim et al (2012)[75]	For all food ads across all hours, the 2010 sample had significant decreases in total advertising budget (− 31%, $P < 0.05$), number of ads placed (− 58%, $P < 0.01$), and GRPs (− 58%, $P < 0.01$) compared with the 2009 sample. During regulated hours (5:00–7:00 PM): • EDNP advertising budget dropped 77% ($P < 0.01$) • Number of EDNP ads placed dropped 81% ($P < 0.01$) • GRPs for EDNP food ads dropped 82% ($P < 0.01$) During nonregulated hours: • EDNP advertising budget did not decrease significantly • Number of EDNP ads placed dropped 52% ($P < 0.05$) • GRPs for EDNP food ads dropped 50% ($P < 0.05$)	". . .Results suggested that within only one year, such a regulation can have a positive impact on the health environment by inducing changes in the TV advertising practices of South Korean food companies. Through these changes, the regulation may contribute to decreasing children's exposure to the promotion of unhealthy foods, thereby creating a protective environment and facilitating child health improvement in South Korea."	Strengths: • Sampled quarterly to account for seasonal changes (including months on/off school year) • Examined multiple quantitative outcome measures Limitations: • Relatively short-term results, and postimplementation sample only captures 1 month truly postregulation, as enforcement date was pushed back to September • Did not examine any qualitative changes in content (eg, use of techniques that appeal to children) • Only examined changes in TV advertising; didn't capture any changes in EDNP marketing or advertising via other channels/strategies
Lee et al (2013)[76]	EDNP food companies reported significantly greater changes than did non-EDNP companies for Product, Price, and Promotion, but not Place, because of restrictions. • Significantly more EDNP companies reported reducing energy by lowering free sugar content ($P = 0.031$) and reducing fat and *trans* fatty acid content ($P = 0.023$ and $P = 0.018$, respectively). • A significantly greater percentage of EDNP companies fortified with vitamins or minerals ($P = 0.014$) or with protein ($P = 0.022$). • Significantly more EDNP companies introduced online marketing ($P = 0.014$), mobile marketing ($P = 0.042$), and social marketing ($P = 0.042$). • Most companies reported no effect on production costs and/or product sales prices.	". . .Restrictions on TV food advertising may contribute to improvement of the food environment for children's health by encouraging EDNP companies to adjust their products to become more health friendly. Additional positive changes could be expected in the long term, because the current study was performed 1 year after the introduction of these regulations. However, the results showed that some food companies employed strategies to bypass the regulations by changing marketing channels from TV to others or by reducing products' serving sizes. Therefore, it is imperative that efforts be made to determine optimal ways to prevent food companies from bypassing these regulations and that the regulation be extended from to other marketing channels."	Strengths: • Assessed multiple aspects of marketing mix, rather than focusing solely on TV advertising Limitations: • Study findings based on self-report by food company marketers or R&D managers via online survey (with a response rate of 58%, ie, 63 of 108 companies completing the survey) • Relatively short-term results (1 y postimplementation) • Definitions of EDNP vs non-EDNP companies were broad and thus the number of EDNP companies may have been overestimated

(continued)

Table 3 **Continued**

Reference	Key findings	Author conclusions	Strengths and limitations
Ireland (Children's Advertising Code, implemented 2005;[30] superseded by BAI Children's Commercial Communications Code, implemented 2013[40])			
Tatlow-Golden et al (2016)[77]	55.2% of food and beverage ads in the Republic of Ireland and 53.5% in Northern Ireland advertised HFSS products.[38] Dedicated children's channels showed fewer food ads (< 1/h) than general commercial TV channels (up to 5.8/h). Audience panel research indicated, however, that young children view more general TV channels than children's channels. Young children (ages 4–6 y) in the Republic of Ireland were exposed to an estimated 2.84 TV ads for less healthy foods per day (1037/y), compared with 1.87/d (683/y) in Northern Ireland. 71.9% of all food ads would not be permitted to be advertised to children if the WHO Nutrient Profile Model was used. Compared with ads for healthy foods, ads for HFSS foods significantly more frequently evoked taste/aroma, humor, and novelty; ads for healthy foods referred significantly more frequently to fun/play, magic, imagination, and physical activity and were also significantly more likely to employ a nutrition/health claim or to have disclaimers on screen.	"The [island of Ireland's] 'advertised diet' viewed by young children primarily features dairy and fast foods, pizza, sweets and chocolate, normalizing this consumption and associating it with taste/aroma, fun, magic/imagination, physical activity, humor and exaggerated pleasure. HFSS ads primarily featured taste/aroma, humor and novelty. Despite complying with statutory regulations, more than half of IoI [island of Ireland] food advertisements featured HFSS items; young children see over 1000 HFSS ads annually in the Republic of Ireland, nearly 700 in Northern Ireland. Policy implications for remedying children's HFSS ad exposure include (i) applying food advertising restrictions to times when higher proportions of young children watch television—not just child-directed programing—as well as to digital media, (ii) employing a stricter nutrient profiling method and (iii) normalizing children's 'advertised diet' by exploring ways to advertise healthy foods."	Strengths: • Sampled TV channels and broadcast times most likely to have high viewership among young children • Compared nutritional analyses using multiple nutrient profiling models Limitations: • Sampling based on viewing patterns of children aged 4–6 y may have underestimated older children's exposure, as older children view even more programing that is not solely child-directed • Channel and time selections were based on an audience panel from the Republic of Ireland only (Northern Ireland viewing data was not available) • Study sampled from only 1 time of year (autumn-winter) and thus could not capture potential seasonal shifts in advertising • Only examined changes in TV advertising; didn't capture any changes in EDNP marketing or advertising via other channels/strategies
Quebec, Canada (Consumer Protection Act,[58] implemented 1980, updated guidance issued 2012[59])			
Dhar & Baylis (2011)[78]	French-speaking households with children in Quebec were 13% less likely than English-speaking households to consume fast food each week ($P < 0.05$).	". . .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. . . .We find that it is primarily French-speaking children who are affected by the Quebec ban, while English-speaking children—who have greater access to media from the neighboring U.S. states and Canadian provinces—are less affected. This finding indicates that media spillover can blunt the effect of an advertising ban, which suggests that a ban imposed by a single state or province may not be effective if there is substantial media overlap and that advertising regulations are likely to be more effective if several jurisdictions can coordinate their effort."	Strengths: • Large sample size • Data gathered at multiple points over relatively long period • Difference-in-difference-in-difference approach used to identify households most and least likely affected by the ban (ie, French-speaking and English-speaking households in Quebec and Ontario, as well as households with/without children) • Models controlled for many possible demographic covariates and for year-specific and seasonal effects on outcome measures Limitations: • Unable to examine data from before the ban (data not available) • Data on expenditures not linked to exposure to HFSS food marketing • FOODEX and Famex data is self-reported; potential for misreporting • Examined only 1 food category: fast food • Focused on urban areas; may not be generalizable to smaller cities rural locations

(continued)

Table 3 **Continued**

Reference	Key findings	Author conclusions	Strengths and limitations
Potvin Kent et al (2011)[79]	Overall frequency of food and beverage advertising was similar across all 3 groups (French- and English-speaking Quebec and English-speaking Ontario). Compared with the preferred viewing of both English groups, the preferred viewing of Quebec French children featured the following: • less frequent use of fun child appeals ($P < 0.001$) • fewer appearances of media characters or celebrities ($P < 0.04$) • fewer food and beverage contests ($P < 0.05$) • fewer ads for candy and snacks ($P < 0.001$) and grain products ($P < 0.004$) • more ads for beverages ($P < 0.01$) While fewer French Quebec food ads targeted preschoolers, children, or teens ($P < 0.001$), up to 30% of food ads that aired during French Quebec children's preferred viewing still targeted children.	"The Quebec advertising ban does not appear to be limiting the amount of food/beverage advertising seen by children aged 10–12. However, food categories and marketing techniques used differ in the preferred viewing of French Quebec children.. . .A focus on TV marketing is not sufficient. More research on the influence of broadly based marketing bans is clearly needed."	Strengths: • Authors analyzed what children actually watched, per viewing diaries, rather than relying on ratings data to determine children's preferred viewing times Limitations: • Small child sample used to establish preferred TV viewing; not randomly selected, may not be representative; narrow age range • Relied on children's self-report to determine preferred viewing times • Possible nonrepresentativeness of days used for TV diaries/recordings • Narrow scope for child appeal techniques (only examined use of "fun" themes and characters/celebrities) • Only examined changes in TV advertising; didn't capture any changes in HFSS food marketing or advertising via other channels/strategies • Authors' definition of children's preferred viewing was not consistent with the Consumer Protection Act's 15% viewership threshold, so results cannot be viewed as a direct evaluation of the Act
Potvin Kent et al (2012)[7]	The majority of advertised products in all 3 markets (65%) were classified as "less healthy" using both nutrition profiling systems. Both English groups included significantly more ads for "less healthy" foods and beverages than did the Quebec French group ($P < 0.001$). Compared with both English groups, Quebec French ads featured products significantly lower in sugar, total carbohydrates, and energy per 100 g and as percentage of energy and significantly higher in total fat, saturated fat, *trans* fat, and protein per 100 g and as percentage of energy ($P < 0.05$ for all).	"Our research suggests that, regardless of the advertising policy environment, children aged 10–12 years in Ontario and Quebec are viewing significant amounts of food and beverage advertising and, that overall, the nutritional quality of food advertisements seen on television is not in line with recommended nutritional guidelines.. . .[The Quebec law] does seem to have some minor influence on the healthfulness of these advertisements, however, the majority of advertisements viewed by children still remain unhealthy."	Strengths: • Authors analyzed what children actually watched, per viewing diaries, rather than relying on ratings data to determine children's preferred viewing times • Used broad (inclusive) definition of food and beverage promotions • Testing was conducted using multiple nutritional criteria. Results reported specific nutrient densities and their contribution total energy, in addition to more common binary coding (ie, healthy vs less healthy) Limitations: • For child and TV samples: same limitations as previous study[77] (sample size, representativeness, self-report, limited duration of sample period) • Excluded food and beverage brand ads (such as those for fast food restaurants) because of inability to include nutrition data (22 of 449 ads) • Authors' definition of children's preferred viewing was not consistent with the Consumer Protection Act's 15% viewership threshold, so results cannot be viewed as a direct evaluation of the Act

(continued)

Table 3 **Continued**

Reference	Key findings	Author conclusions	Strengths and limitations
Potvin Kent et al (2013)[80]	There was no significant difference in the number of French (31%) and English (35%) websites with child-directed content or in the frequencies or average number of the various marketing features between English and French websites. Spokescharacters and advergames were present on the majority of English (52% and 70%) and French (50% and 55%) websites. Child protection features were present on 15% of English websites and on 18% of French websites. 41% of English websites and 46% of French websites encouraged a physically active lifestyle.	"Systematic surveillance of the Consumer Protection Act in Quebec is recommended. In the rest of Canada, the [self-regulatory Canadian Children's Food and Beverage Advertising Initiative] needs to be significantly expanded or replaced by regulatory measures to adequately protect children from the marketing of foods/beverages high in fat, sugar, and sodium on the Internet.…Given that the border of Internet regulations is permeable, international agreements between countries will be necessary."	Strengths: • Quantified prevalence of food marketing in regulated and nonregulated websites (1 of the first evaluations to examine websites) • Analyzed website content to examine marketing strategies used • Website sample likely represented heavily advertised foods, as websites were selected on the basis of TV ads aired during children's preferred viewing Limitations: • For child and TV samples: same limitations as previous study[77] (sample size, representativeness, self-report, limited duration of sample period) • Websites were not randomly selected, and results are therefore not generalizable to all Canadian food and beverage websites

Abbreviations: ad(s), advertisement(s); BAI, Broadcasting Authority of Ireland; EDNP, energy-dense, nutrient-poor; GRP, gross rating point; HFSS; high in saturated fat, salt, or sugar; OR, odds ratio; PMVs, person minute views; R&D, research and development; WHO, World Health Organization.

examined household HFSS food and drink expenditures and industry advertising expenditures pre- and postimplementation of broadcast restrictions found that post-implementation spending on TV ads promoting HFSS food products declined (−19.4%), but this was partially offset by increases in non-TV HFSS food advertising.[73]

Finally, a postregulation content analysis of TV advertisements on the island of Ireland (comparing broadcasts recorded in Northern Ireland and the Republic of Ireland) found that, despite regulations in both jurisdictions, over half of food advertisements were for HFSS products, and children continued to have high levels of exposure to advertisements for these products.[77]

Comparison of policies in Chile and the United Kingdom. Table 4[37,38,50–53,67,68] presents a detailed comparison of Chile's and the United Kingdom's approaches to food marketing regulation. The United Kingdom's BCAP Code was implemented in 2008, with a subsequent code on non–broadcast advertising implemented in 2017. Chile's Law on Nutritional Composition of Foods[45] was implemented in June 2016 and amended by the Law on Food Advertising[52] implemented in May 2018. While both the United Kingdom and Chile were among the first countries to specifically restrict HFSS food marketing to children, and the populations protected under the regulation are similar (children aged 4–16 years in the United Kingdom and < 14 years in Chile), there are notable differences between these regulations.

First, while the Chilean regulations are statutory and are overseen by a governmental body (the Ministry of Health), the UK broadcast code is coregulatory between the government and the advertising industry. The United Kingdom's non–broadcast code is entirely self-regulated by advertisers. In practice, while the UK government's Office of Communication (Ofcom) is legally responsible for the broadcast code, agencies funded by or comprised of members of the advertising industry actually write, monitor, and enforce both the broadcast and non–broadcast codes, which has raised questions about the objectivity of monitoring and enforcement efforts.[89] The UK broadcast code does require companies to submit advertisements for approval to a media-specific preclearance body (also funded by advertisers), which is intended to prevent ads for HFSS food or beverage products from being placed during restricted broadcasting.[90] Penalties for violating the UK codes vary by media type. For online advertising, for example, the Advertising Standards Authority (ASA) uses a "name and shame" approach in which violators are listed on the ASA website.[91] For both broadcast and non–broadcast media, the ASA can also request that an ad be amended or removed and can refer repeat

offenders to other bodies for additional review, but it is not always clear what this process or possible sanctions entail.[92] Under the BCAP Code, for example, broadcasters that "persistently run ads that fall foul of the Broadcast Advertising Code" can be referred by the ASA back to Ofcom, which can impose fines or withdraw the broadcaster's license.[92]

In contrast, the Chilean regulation does not require preclearance of ads. The Chilean Ministry of Health monitors and enforces its marketing policy by coordinating a regulation control action plan, which is implemented by regional health authorities.[93] Two additional governmental organizations assess compliance and provide reports to the Ministry of Health on compliance with the TV advertising regulations. The public can report violations through the Ministry of Health and the National Consumers Service, which then report to the regional health authorities for an investigation and inspection. Depending on the findings of the investigation, the company can be given a reprimand, fined (up to 1000 monthly tax units), or prohibited from selling the product. Despite these differences in monitoring and enforcement, governmental agencies have reported high levels of compliance with regulations in both Chile and the United Kingdom.[90,93,94]

Additional key differences between these countries' regulations are related to elements of policy design. For example, to identify HFSS foods and beverages, the UK codes use a nutrient profiling model[38] that allocates points for healthy or beneficial nutrients/ingredients and points for less healthy nutrients/ingredients, and then subtracts "healthy" points from "unhealthy" points to achieve a final score that determines which products are less healthy or HFSS.[38] This model has been demonstrated to be more effective at capturing HFSS products than industry profiling schemes used in the United States and the European Union but less effective than a model used in other nutrient profile models.[95] Public Health England is in the process of reviewing and modifying the model to "bring it in line with current UK dietary recommendations,"[96] which may increase the number of products classified as HFSS. In contrast, the Chilean model focuses only on nutrients of concern and does not incorporate beneficial nutrients. The Chilean regulation defines "high in" products as foods or beverages that contain free (added) sugar, sodium, or saturated fat and that also exceed set nutrient density thresholds for these nutrients and/or energy (in kilocalories). These nutrient thresholds grew significantly more strict from the first phase of implementation in 2016 to the final implementation phase in 2019 (eg, the sugar threshold decreased from 22.5 g of sugar per 100 g or 100 mL in 2016 to 10 g of sugar per 100 g or 100 mL in 2019), so the number of products that fall under regulation will likely increase unless products are reformulated. For example, a recent study on TV advertising prior to the Chilean regulations found that 34% of TV ads in Chile contained at least 1 HFSS product when 2016 thresholds were used to classify HFSS products, but 47% of TV ads contained an HFSS product when the 2019 thresholds were used.[97] Both the UK and Chilean models use ingredient or nutrient content per 100 g or 100 mL portion; both are applied consistently across all food and beverage categories (as opposed to using different requirements for different food groups); and neither allows for exemptions by product or category type.

Regarding communication channels covered, both Chile and the United Kingdom restrict HFSS food advertising on websites that target children or have a child audience share greater than 20% (Chile) or greater than 25% (United Kingdom) as well as during TV programs on devoted children's channels or during TV programs that target children. Chile defines these as programs as having greater than 20% child viewers out of total viewers, whereas the United Kingdom defines these as programs for which the child audience exceeds a "120 Index" ([percentage of all children aged 4–15 years watching ÷ percentage of people watching out of the total population] × 100). Both formulas can lead to large gaps in coverage, as a program with high viewership from all ages can have a relatively low proportion of child audience, even with a high absolute number of children watching the program. In addition, the Chilean formula is not robust to population shifts: If the population ages (ie, birth rate decreases, as is the current trend in industrialized countries), the ratio of children to adults in the viewing audience would need to be more pronounced (ie, more child viewers needed) to reach the 20% cutoff. However, starting in June 2018, Chilean TV restrictions were expanded to prohibit HFSS food advertising on all TV (and cinema) from 6:00 AM to 10:00 PM to all age groups, except during sporting and cultural events that meet certain criteria. This is the most expansive scheduling restriction on TV advertisements for HFSS foods in any country to date. Chile's regulation also prohibits marketing and sales of these products inside of schools, whereas the UK codes do not.

Compared with the UK codes, Chile's law also defines a larger range of more specific types of marketing techniques that appeal to children and are prohibited for use in HFSS marketing, regardless of media placement. A key difference is that, while both the United Kingdom and Chile prohibit the use of licensed characters, Chile's policy has also effectively limited the use of brand equity characters or mascots that appeal to children (eg, Kellogg's Tony the Tiger). The Chilean

Table 4 **Policies in Chile and the United Kingdom to restrict unhealthy food and beverage marketing to children**

	Chile	United Kingdom	
		Broadcast media	Non–broadcast media
Laws or codes	Law No. 20.606 on Nutritional Composition of Food and Food Advertising (Ley 20.606[50,51]), amended by Law No. 20.869 on Food Advertising (Ley 20.869[52,53])	The UK Code of Broadcast Advertising[37] (BCAP Code)	The UK Code of Non–broadcast Advertising and Direct and Promotional Marketing[67,68] (CAP Code)
Date of implementation	June 27, 2016 (Ley 20.606; phased implementation through June 27, 2019[a]); May 29, 2018 (Ley 20.869)	Phased implementation: April 1, 2007–January 1, 2009[b]	July 1, 2017
Regulatory bodies, monitoring, and enforcement	• Ministry of Health: monitors and enforces via a "regulation control action plan" • Regional health authorities: implement regulation control action plan, investigate complaints • The National Council of Television (Televisión Nacional de Chile) and the National Consumers Service (SERNAC): assess compliance and provide monthly reports to the Ministry of Health • Penalties for violations: reprimand, fines (up to 1000 monthly tax-units), prohibition from selling advertised product	• Advertising Standards Authority (ASA): self-regulatory organization of UK advertising industry; applies and enforces codes • Committee on Advertising Practice (CAP): organization of UK advertising industry; writes codes • UK Office of Communications (Ofcom): governmental body responsible in law; contracts ASA to regulate broadcast advertising • Preclearance bodies (vary by media): check that commercials meet code and that claims can be substantiated • Penalties for violations: persistent violators can be referred by ASA to Ofcom, which can impose fines or withdraw the broadcaster's license	• Advertising Standards Authority (ASA): self-regulatory organization of UK advertising industry; applies and enforces codes • Committee on Advertising Practice (CAP): organization of UK advertising industry; writes codes • Penalties for violations: "name and shame" policy (violators listed on ASA website); request for ad to be amended or removed; referral for repeat offenders to other bodies for additional auctioning/sanction
Nutrition criteria: How is it determined which foods and beverages are included/excluded?	If a product contains free (added) sugar, added sodium, or added saturated fat *and* exceeds set nutrient thresholds per 100 g (of food) or 100 mL (of beverage), it is considered a "high in" product and is subject to regulation. Thresholds have been implemented in phases with increasing stringency,[a] and, as of the final phase in June 27, 2019, will be as follows: 275 kcal/100 g of product (70 kcal/100 mL for beverages), 400 mg of sodium/100 g (100 mg/100 mL), 10 g of total sugar/100 g (5 g/100 mL), or 4 g of saturated fat/100 g (3 g/100 mL). No food or beverage groups are exempt, and there are no category-specific criteria for foods or beverages.	Nutrient Profiling Model[38]: Points are allocated for nutrient content per 100 g of product. Points for 'C' nutrients (fruit, vegetable, nut, fiber, and protein content) are subtracted from points for "A" nutrients (energy, saturated fat, total sugar, and sodium) to get a final nutrient profile score. Foods that score $>$ 4 points and beverages that score $>$ 1 point are classified as "less healthy" (HFSS) and are subject to regulation. No food or beverage groups are exempt, and there are no category-specific criteria within foods or beverages.	Nutrient Profiling Model[38]: Points are allocated for nutrient content per 100 g of product. Points for 'C' nutrients (fruit, vegetable, nut, fiber, and protein content) are subtracted from points for "A" nutrients (energy, saturated fat, total sugar, and sodium) to get a final nutrient profile score. Foods that score $>$ 4 points and beverages that score $>$ 1 point are classified as "less healthy" (HFSS) and are subject to regulation. No food or beverage groups are exempt, and there are no category-specific criteria within foods or beverages.

(continued)

Table 4 **Continued**

	Chile	United Kingdom	
		Broadcast media	Non–broadcast media
Definition of children	< 14 years of age	4–15 years of age (< 12 years of age for restrictions on marketing techniques)	< 16 years of age
Exposure: Method of determining communication channels and settings subject to restrictions	Time of day (for TV and cinema): from 06:00–22:00 Content: on dedicated children's channels or websites; during programs/movies or on websites targeting children Audience: when child audience share exceeds 20% Exception: advertising for "high in" products permitted during restricted hours or under some conditions for sports, cultural, artistic, or charity events if certain criteria are met	Audience indexing: exceeds 120 Index (ie, programming is considered appealing to children if indexing score exceeds 120 for [percentage of all children aged 4–15 y watching ÷ percentage of people watching out of the total viewing population] × 100) Content: on dedicated children's channels; during or adjacent to programs appealing to children (determined using the 120 Index)	Audience: when child audience share exceeds 25% Content: in media specifically for children
Media to which restrictions apply	TV, cinema, the internet/online[c], marketing in school settings	TV, radio	Cinema, video, DVD, Blu-Ray, the internet/online[d], mobile, signs and outdoor media, direct mail, sales promotions
Power: Restrictions on use of persuasive marketing techniques/creative child appeals	Any form of marketing for "high in" products may not use the following: • Characters, child figures, animations, or cartoons (brand equity characters are considered to meet these descriptions and are thus not allowed) • Children's music • Premiums, toys, accessories, or stickers • People or animals that capture children's interest • Statements or fantastic arguments about the product or its effects • Situations that represent children's daily life, expressions, or language • Interactive applications, games, contests • "Hooks" not related to the product itself	In all media covered by the BCAP Code, if ad is for HFSS product(s) and directly targets children < 12 y, ad may not use the following: • Licensed characters • Celebrities popular with children • Promotional offers Use of brand equity characters is not restricted	In all media covered by the CAP Code, if ad is for HFSS product(s) and directly targets children < 12 y, ad may not use the following: • Licensed characters • Celebrities popular with children • Promotional offers Use of brand equity characters is not restricted
Media to which restrictions apply	TV, radio, cinema, the internet/online[c], mobile, interactive games, print, signs, and outdoor media; Direct marketing, packaging, point-of-sale, product placement, sponsorships, marketing in school settings, marketing at events/venues	TV, radio	Cinema, video, DVD, Blu-Ray, the internet/online[d], mobile, signs and outdoor media, direct mail, sales promotions

(continued)

Table 4 **Continued**

	Chile	United Kingdom	
		Broadcast media	Non–broadcast media
Other features:			
Packaging	Mandatory FOP warning labels are required on packages for "high in" foods	N/A	N/A
Marketing in schools	"High in" products cannot be sold or advertised inside preschool, elementary, or secondary schools	N/A	N/A
Health/nutrition claims	Health/nutrition claims are permitted in ads or on packaging for "high in" products, but claims may not refer specifically to the "high in" nutrient(s)	No nutrition or health claim may be used in TV or radio HFSS product advertising targeted directly at children aged $<$ 12 y	Claims referring to children's development and health are permitted if authorized by the European Commission
Disclaimers	Advertising for "high in" products must carry disclaimer: "Choose foods with fewer logos"	N/A	N/A

Abbreviations: ad(s), advertisement(s); DVD, digital video disc; FOP, front-of-package; FSS, high in fat, salt, or sugar; HFSS; high in saturated fat, salt, or sugar; N/A, not applicable.

[a]Chile's phased nutrient threshold implementation schedule: *June 27, 2016*: 350 kcal/100 g of product (100 kcal/100 mL for beverages), 800 mg of sodium/100 g (100 mg/100 mL), 22.5 g total sugar/100 g (6 g/100 mL), or 6 g of saturated fat/100 g (3 g/100 mL). *June 27, 2018*: 300 kcal/100 g of product (80 kcal/100 mL for beverages), 500 mg of sodium/100 g (100 mg/100 mL), 15 g of total sugar/100 g (5 g/100 mL), or 5 g of saturated fat/100 g (3 g/100 mL). *June 27, 2019*: 275 kcal/100 g of product (70 kcal/100 mL for beverages), 400 mg of sodium/100 g (100 mg/100 mL), 10 g of total sugar/100 g (5 g/100 mL), or 4 g of saturated fat/100 g (3 g/100 mL).

[b]BCAP Code phased implementation: *April 1, 2007*: ads for HFSS products not permitted in/around programs made for children or in/around programs likely to be of particular appeal to children aged 4–9 y. *January 1, 2008*: ads for HFSS products not permitted in/around program likely to be of particular appeal to children aged 4–15 y. *January 1, 2009*: ads for HFSS products not permitted on dedicated children's channels.

[c]Chile's law does not explicitly list all types of online media but is intended to apply to the full breadth of online media.

[d]Includes online ads, UK-based company websites, social media sites, video-on-demand, text messages, email, advergames, and viral ads.

policy also prohibits the use of movie tie-ins, cartoons, child figures, interactive games, applications, contests, child voices and actors, and references to children's lives such as playgrounds or school settings as well as the offering of premiums such as toys, accessories, or stickers. These elements are prohibited in HFSS marketing across all media—not just those covered by ad placement restrictions—and on food and beverage packaging, which is not restricted under UK policy. For example, the use of a cartoon bear would be prohibited on the box of an HFSS breakfast cereal in Chile, whereas it would be permitted in the United Kingdom.

The policies also differ with regard to other types of information that can be conveyed on packages or in advertisements. The Chilean policy is unique in that all products that have marketing restrictions must also carry front-of-package warning labels (eg, "high in sugar"). These warning labels could increase the law's salience for consumers by signaling to them that the product is subject to marketing restrictions, presumably making it easier for the public to identify and report violations of the regulation. When HFSS food advertisements are permitted (eg, between 10:00 PM and 6:00 AM), Chile requires a disclaimer on all HFSS food advertisements advising consumers to "choose foods with fewer warning labels"). In contrast, the United Kingdom has a separate policy that allows for voluntary use of front-of-package "traffic light" labels.[98] This policy is not linked to the marketing policy and, to the best of knowledge, does not require the use of disclaimers on HFSS food advertisements. Finally, the Chilean policy has minimal restrictions on the use of health or nutrition claims: packages or advertisements for HFSS products may feature health/nutrition claims, provided they do not refer specifically to the regulated nutrients that the product contains in excess. The United Kingdom's BCAP Code bans the use of any nutrition or health claim in TV or radio HFSS food advertisements that directly target children under age 12, but the CAP Code permits claims in marketing for HFSS products in all non–broadcast media, only requiring that they be supported by evidence.

The Chilean and UK regulations also share some important limitations. For example, neither prohibits the use of price promotions, in-store product placement, multipack strategies, or other key point-of-sale forms of marketing for HFSS products. Neither country restricts brand advertising, thereby allowing companies to promote brands that may contain both HFSS and non-HFSS products, nor do the regulations of either country restrict corporate sponsorships of sporting events or teams, thereby allowing companies to promote HFSS products both at local-level sporting events and at large national or international sporting events.

DISCUSSION

The results of this review show that there are relatively few governmental policies to reduce food marketing. For example, only 16 jurisdictions were found to have statutory food marketing regulations meeting study criteria. Of those, 10 jurisdictions specifically restrict unhealthy food marketing to children, while the remaining 6 restrict marketing of all commercial products to children. In contrast, 36 countries currently have health-related food or beverage taxes.[99] With the exception of Quebec's and Norway's regulations, however, the remaining marketing policies included here have all been implemented since 2007, suggesting that such regulations are becoming more common.

In addition, few studies have been published evaluating governmental policies on reducing unhealthy food marketing to children. Most evaluations to date have either examined only short-term changes in exposure and power of TV food advertising or have consisted of cross-sectional comparisons between groups considered more vs less likely to experience a policy's effects. The majority of these evaluations have found relatively small policy-related reductions in TV advertising for HFSS food and beverages, with some evidence that these reductions are offset by increases in HFSS food advertising during unrestricted broadcasting or via marketing in other media. Few studies examined changes in marketing across multiple media, however, making it difficult to understand changes in the overall prevalence of HFSS food marketing.

Relatively small reductions in unhealthy food advertising could also result from weak policy designs. Most existing regulations cover a limited scope of media formats, and restrictions on TV advertising often apply only to dedicated children's programming or very narrow windows of time. The Chilean regulation is the first to limit placement of TV ads for HFSS products both on children's programs and on all general audience programs from 6:00 AM to 10:00 PM, but this approach has not yet been evaluated, so the effects of the additional time-based restriction on children's exposure to HFSS food marketing are unknown. In general, this review found the Chilean regulation to be more comprehensive than the UK regulation, both in scope of communication channels covered and in restrictions on marketing techniques. However, neither country's regulations placed any limits on corporate sponsorship, which could allow high levels of unhealthy food marketing during sports, cultural events, or other activities. More

research is needed on the effects of each country's policies.

There is, of course, a tradeoff between policies that may be optimal in their potential to impact health and those that are politically feasible. Indeed, considerable homogeneity was found across some design components, such as the age of children protected, along with heterogeneity among other components, such as which foods are included. More research will be needed to identify which policy components are most critical for a regulation to effectively reduce children's exposure to unhealthy food marketing, improve children's diet, and prevent obesity. A discussion of key policy features, the implications of these in existing regulations, and the research needed for evidence-based policy design follows.

Which children receive protection. The results show that most food marketing regulations to date have focused on protecting preadolescent children aged 12 to 15 years or younger, in line with evidence that food marketing influences younger children's nutrition knowledge, perceptions, preferences, purchases, and intake.[9,100] Evidence for a causal effect of food marketing on older adolescents' knowledge, preferences, purchases, and intake is less clear.[1] However, because older adolescents remain vulnerable to advertising and have increased purchasing power, and because eating patterns and weight status in adolescence track into adulthood, the inclusion of adolescents up to age 16 to 19 years could have important implications for diet and obesity.[89,100] Future research will be needed to identify the optimal age range of children to protect from HFSS food marketing in order to develop healthy preferences and eating behaviors across the lifespan.

Which foods and beverages are covered. All policies intended specifically to limit food marketing use a nutrient profile model to identify products to be restricted. However, about half of these countries apply the nutrient profile model to all foods and beverages, whereas the others apply the model only to certain food and beverage categories or used varying, category-specific nutritional criteria. Two countries apply additional restrictions to entire categories of food, regardless of the nutrient profile of the categories. This latter approach is similar to that recommended by the WHO Regional Office for Europe, which stipulates that entire categories of products should be restricted from marketing, regardless of their nutritional content (eg, chocolates and candies, cakes and grain-based desserts, juices, energy drinks), while other categories are subject to meeting nutrient thresholds to determine eligibility.[82] Which model should be used to identify which foods get restricted likely depends on the policy's goals. For example, policies that use nutrient thresholds may be more likely to incentivize reformulation as a strategy for avoiding the marketing restriction, whereas policies that restrict entire categories are less likely to incentivize reformulation, since a product would still receive the marketing restriction regardless of its nutritional content. Similarly, category-specific nutrient thresholds might encourage consumers to shift to healthier products within a category, whereas nutrient thresholds applied to all foods and beverages might encourage consumers to choose fewer HFSS products overall (ie, less within-category shifting but an overall downward shift with regard to critical nutrients). More research will be needed to understand how both industry and consumers respond to different nutrient profile models in food marketing policies.

Most countries' nutrient profile models include saturated fats, sugars, and sodium, consistent with a recent study of nutrient profile models for government-led policies on obesity and noncommunicable diseases.[101] Few countries include *trans* fats in their nutrient profile model, possibly because few countries have mandatory labeling on *trans* fats.[102] Similarly, most countries specify limits on total sugar rather than on free sugar, as recommended by WHO, possibly owing to lack of information about free sugars on labels or in food-composition databases. The Chilean regulation addresses this by first determining whether a product contains added sugar as an ingredient in the product and then applying a total sugar threshold, thereby eliminating the need for an actual amount of added sugar to be stated. This option provides a relatively easy solution to identifying added sugar without labels. However, with this approach, products that contain relatively high levels of natural sugar will more rapidly exceed the total sugar threshold, even if they have a relatively smaller amount of added sugar. The degree to which free or total sugars should be prioritized is controversial and changing, with more policy-oriented nutrient profile models increasingly emphasizing free sugars.[101]

A relatively unexplored feature of nutrient profile models that has marketing implications as well as nutritional implications is whether the model is based on the volume or weight of a product, on total calories, or on portion sizes. In Chile, where nutrients per 100 g of food or per 100 mL of beverage is used as the basis for the nutrient profile model, the food industry has argued for the use of portion sizes instead.[103,104] This contention has played out in changes to product marketing. For example, the use of nutritional messages based on portion sizes has increased. On a box of chocolate children's cereal, for instance (see Figure S1 in the Supporting Information online), next to 2 warning labels stating the product is high in sugar and high in

calories appear images of cups with text stating that 100 g equals 3.5 suggested portions (30 g or ¾ cup), along with an image indicating that a single portion of the cereal contains only 8.6 g of sugar. It is unclear what effect these marketing strategies have on consumers' understanding of nutritional knowledge or their perceptions or purchases of these products. Future research will be needed to understand the effects of nutritional profiles, not only on the nutritional impact of the law but also on industry's response, including changes in food marketing strategies.

How exposure to food marketing is limited. The communication channels covered by a policy affect how much the policy is likely to reduce children's exposure to food marketing across their environment. This review found that most existing regulations apply to very limited communication channels. The most common settings covered are TV and school, with few regulations applying to digital media, packaging and point-of-sale settings, events and sponsorships, print media, and others. Limiting coverage to only a few communication channels (eg, only broadcast media)—or even covering all media but excluding nonmediated venues (eg, sports arenas)—allows companies to shift HFSS food marketing to channels and venues that are not regulated, reducing the impact of policies on children's exposure to unhealthy food marketing. To avoid this, policymakers could apply restrictions across all print and electronic media and could also include nonmediated venues, such as corporate sponsorship of sporting or cultural events and educational settings. More research will be needed to understand industry response to limitations on different channels, as well as which communication channels are most important for reducing children's exposure.

Another important consideration is how to identify, within each communication channel, the content to which children are likely to be exposed and thus what should be restricted. Most existing regulations use either audience definitions to identify programs that disproportionally attract child audiences or location-based definitions in which the surrounding content is intended for children. Many statutory regulations and industry pledges, alike, rely on relatively high thresholds for child audience share (ranging from 15% to 30%) to identify child-directed media. Lower thresholds will capture more programming,[105] including more programs oriented toward a general audience, because children are permitted to comprise a smaller percentage of viewers. In contrast, higher thresholds will capture less programming overall but more programs that are intended for children specifically. The appropriate threshold level may depend, in part, on whether a time-based restriction is also used, as the latter can address programs that are popular with children but also watched by adults.

In addition to the child audience threshold used, the formula used to calculate child audience share can also affect how much food marketing exposure is prevented. For example, if the formula depends on the percentage of children in the total population (such as in the Chilean regulation), the amount of programming included could increase or decrease, depending on whether birth rates increase or decrease. This problem can be addressed by using measures that are not dependent on the population distribution, such as comparing the relative reach of a program among children to the relative reach of the program among adults (eg, TV rating for children vs TV rating for adults), as in the UK regulation. This simpler ratio redirects the focus of the formula to directly assess whether the proportion of children exposed to a marketing message (out of all children in the TV universe) is equivalent to, if not lower than, the proportion of adults exposed (out of all adults in the TV universe).

Specific definitions for time-based restrictions on TV broadcast advertising are also used in 4 countries. Mexico and Taiwan use time-based definitions to determine when other child audience thresholds (Mexico) or restricted placement on children's channels (Taiwan) should apply. South Korea combines a modest time-based restriction (5: 00 PM to 7: 00 PM) with a restriction on placement during children's programming. Chile has by far the broadest time-based restriction (6:00 AM to 10 PM) and also applies child audience thresholds outside of restricted times. Time-based restrictions have the advantage of reducing children's advertising exposure to media that appeal widely to both children and adults, rather than to media that only appeal to children. This is important, because programs that have high levels of coviewing (ie, a large number of children and parents watching together) will have a smaller percentage of child audience, making it more difficult for these programs to be captured by a child audience–based definition. Of course, in order to be effective, time-based definitions will need to include hours when children are viewing media, which may vary by country as well as by sociodemographic factors such as gender, region, or socioeconomic status. Future research will be needed to identify the optimal definitions to reduce children's exposure to unhealthy food marketing. The Chilean regulation, in particular, provides a valuable opportunity to evaluate the differential effects of an audience- and location-based definition vs a time-based restriction, since it implemented the former in 2016 and the latter in 2018.

Reducing the power of advertising. Reducing the harmful effects of HFSS food marketing on children requires not only limiting children's exposure but also limiting the persuasive power of marketing by restricting the use of marketing techniques that appeal to children.[19] This review found that restrictions on the use of free gifts and toys, celebrities, and licensed or other types of characters are most common. Countries or jurisdictions with regulations on all forms of commercial marketing to children, not just food marketing, are less likely to include specific restrictions on child-directed marketing techniques. That is, they are more likely to use broad definitions. Quebec's regulation, for example, simply prohibits advertisements designed to attract children's attention. Currently, there is scant evidence about which approach—using lists of specific techniques or using broad-based definitions—is better. However, identifying which techniques are truly appealing to children can be difficult, as these vary depending on culture, age of the target population (young children vs early adolescents vs later adolescents), and context within the advertisement, among other factors. Moreover, poorly defined restricted techniques can increase the complexity of assessing compliance and can also elicit challenges from industry about the subjectivity of these judgments.

Most regulations focus only on limiting child-directed techniques and not on other techniques that might influence children's consumption of unhealthy foods. For example, health and nutrition claims and messages are highly prevalent,[106] including on children's products like sugar-sweetened fruit drinks,[107] and have been shown to increase misperceptions about the healthfulness of the product (ie, the health halo effect) among both children and adults.[108–112] In addition, some evidence suggests that the use of nutrition-related claims on unhealthy foods and beverages may be increasing as alternative marketing strategies as policies to reduce child-directed food marketing become more widespread.[113,114] Similarly, other techniques, like fruit depictions, can lead children and parents to think a product is healthier, regardless of its actual fruit content.[115,116] More research will be needed to determine which definition of child-directed marketing best captures all marketing that appeals to children and to ascertain the potential effects of expanding this definition to include additional techniques, such as claims or fruit depictions, that target both parents and children.

Finally, most existing food-specific marketing regulations have not addressed marketing for brands—which may produce and sell both HFSS and non-HFSS foods—as opposed to products. For example, a regulation might prohibit commercial advertising for the specific product Coca-Cola during children's programming because of the beverage's high sugar content but permit commercial advertising of the Coca-Cola brand, even though the brand promotes both regular Coca-Cola as well as other products. More research is needed to understand the impact of including restrictions on brands as well as on products as part of unhealthy food marketing regulations.

Monitoring and enforcement. Strong systems for monitoring and enforcement will improve the likelihood that a marketing regulation will reduce children's exposure to unhealthy food marketing. It was difficult to find detailed information on monitoring and enforcement in most countries with regulations. This lack of information is concerning, as both the content of the regulations as well as the process for monitoring and enforcing them should be easily accessible and understood by the general population. In the case of Chile and the United Kingdom, where this information was available (though not always clear or detailed), it was not clear which system is more effective. On one hand, the government oversees and enforces Chile's regulation, whereas the advertising industry largely enforces the UK system, representing a potential conflict of interest. On the other hand, the UK system includes both a prevetting process and complaints as ways of identifying noncompliant advertisements, a process that is recommended by the WHO framework.[26] The WHO framework also notes that penalties for violations should be large enough to disincentivize violations and include publicity about the offense. However, there is virtually no research on the effects of different penalties and what size or type of penalty is sufficient to effectively disincentivize violations. Future research will be needed to evaluate the monitoring and enforcement systems currently in place and to examine how these are associated with the impact of policies.

Evaluating outcomes. Overall, there were relatively few studies evaluating statutory governmental policies. Of the evaluation studies, nearly all focused on what the WHO 2012 food marketing policy framework refers to as *outputs*, or short-term outcomes such as changes in children's exposure to food marketing and changes in marketing techniques, with a dearth of studies on longer-term outcomes, such as changes in food awareness, attitudes or beliefs, industry behavior (eg, product reformulation), consumer behavior (eg, food purchases or intake), and weight status. Of course, most policy evaluations are observational in nature, making it difficult to disentangle the effect of a policy from an ongoing secular trend.[117] Moreover, measuring changes in outcomes like obesity can be complex, given that

obesity is complex and multifactorial, with a long latency period. One option to address this is to examine pre–post changes in children's individual-level exposure to unhealthy food marketing by measuring children's media use and linking this to data on food advertising. Longitudinal measures of food marketing exposure can then be examined along with changes in outcome measures to understand whether reductions in exposure are associated with changes in children's food attitudes, knowledge, perceptions, dietary intake, and health outcomes.[118] In addition, the use of additional data such as sales, expenditures, or household food purchase data can enable a richer understanding of both industry and consumer behavior, and the larger sample sizes typical of these data sources allow assessment of a policy's differential effects by key sociodemographic factors such as socioeconomic status.[117]

Longitudinal research, however, may not always be possible. For example, several of the Quebec evaluations were conducted years after policy implementation; these studies used cross-sectional comparisons between groups of children who were more or less likely to be exposed to Quebec's regulation (depending on their location and language) to examine policy-related effects. While such study designs may not be ideal because of their observational, cross-sectional nature and the time elapsed since the policy was enacted, policy evaluations are often not ideal because researchers are responding to real-life events rather than proactively (and randomly) assigning a treatment. Additional research will be needed to strengthen natural experimental methods to evaluate food marketing policies and their effects on children's exposure to unhealthy food marketing, diet, and health.

Limitations. A major challenge when comparing different policies is understanding the differential effects of various policy design components. For example, if one policy appears to have impacted children's food marketing exposure more greatly than another policy, it is difficult to disentangle whether this was due to the scope of the policy regarding media coverage, the limitations on marketing techniques, the use of stronger nutritional criteria, or something else. Another limitation is that the lack of comprehensive policy evaluations makes it difficult to analyze and identify best practices for reducing children's exposure to unhealthy food marketing through policy action. Standardized monitoring procedures, such as those proposed by the International Network for Food and Obesity/noncommunicable disease Research, Monitoring and Action Support (INFORMAS),[119] could be expanded to include additional outcomes recommended by the WHO 2012 framework, including enforcement of the regulation; exposure to marketing; marketing strategies; effect of marketing on attitudes, preferences, and beliefs; effects on industry behavior; and effects on dietary behavior. Finally, this review is limited only to existing statutory regulations and does not include countries such as the United States, which has voluntary but not statutory regulations. Future research should examine the legal and political feasibility of potential statutory regulations in the United States and elsewhere, including the feasibility of different types of marketing regulations (restrictions on child-directed food marketing, all unhealthy food marketing, or child-directed marketing for any commercial products).

CONCLUSION

Governments are increasingly implementing statutory policies that restrict HFSS food marketing to children, with all food-marketing-specific policies implemented since 2007. While current policies vary with regard to the foods they include, which children are protected, and which communication channels and marketing techniques are covered, there are some commonalities. Most regulations protect children aged 12 to15 years or younger. Restrictions on TV advertising are most common, with most restrictions in effect during children's programs only. Schools are also a common setting. Restrictions on media such as cinema, mobile, print, packaging, and the internet are uncommon. Most policies focus on limiting child-directed marketing strategies such as licensed characters, with little attention paid to other marketing strategies like health and nutrition claims. For the most part, existing evaluations of policies have found small or no policy-related reductions in unhealthy food advertising; however, not all policies have been evaluated. Moreover, there is virtually no evidence on policies' effects on children's food purchases, dietary intake, or weight status. Future research should examine which elements of food marketing policy design are most effective at reducing children's exposure to unhealthy food marketing, improving dietary quality, and preventing obesity.

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Declaration of interest. The authors have no relevant interests to declare.

Supporting Information

The following Supporting Information is available through the online version of this article at the publisher's website:

Appendix S1 **Search terms used in the literature search**

Table S1 **Dimensions of statutory food-marketing policies**

Figure S1 **Example of industry front-of-package messaging relating nutrient warning labels to suggested portion size (from Chile)**

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Article

Obesity prevention and related public health advertising versus competing commercial advertising expenditure in Australia

Ashleigh Haynes[1,2,*], Megan Bayly[1], Helen Dixon[1,2], Alison McAleese[3], Jane Martin[4], Yan Jun Michelle Chen[1], and Melanie Wakefield[1,2]

[1]Centre for Behavioural Research in Cancer, Cancer Council Victoria, 615 St Kilda Rd, Melbourne, VIC 3004, Australia
[2]Melbourne School of Psychological Sciences, The University of Melbourne, Parkville, VIC, Australia
[3]Prevention Division, Cancer Council Victoria, Melbourne, VIC, Australia
[4]Obesity Policy Coalition, Cancer Council Victoria, Melbourne, VIC, Australia
[*]Corresponding author. E-mail: ashleigh.haynes@cancervic.org.au

Summary

Mass media campaigns can change attitudes and behaviours to improve population health. However, a key challenge is achieving share of voice in a complex and cluttered media environment. The aim of this study was to compare advertising expenditure on public health campaigns for obesity prevention (and related healthy eating and physical activity campaigns) with competing commercial categories of (a) sugary drinks, (b) artificially sweetened drinks and (c) diet/weight loss products and programmes. These commercial products may either undermine or dilute public health messages by directly contributing to poor health or confusing the public about the best ways to sustain a healthy lifestyle. Monthly estimates of advertising expenditure in Australian media (television, outdoor, cinema, radio, newspapers, magazines and digital) were obtained from Nielsen Media for 2016–18. Eligible public health advertising expenditure for the entire period (total AUD$27M) was vastly outweighed by the commercial categories of sugary drinks (AUD$129M) and diet/weight loss products and services (AUD$122M). Artificially sweetened drinks accounted for an additional AUD$23M of expenditure. These results highlight the need to rebalance the ratio of advertising to support public health in Australia through increased funding for obesity prevention and related campaigns, and critically, through government regulation to limit competing commercial advertising.

Keywords: advertising, mass media, sugary drinks, obesity prevention, diet

INTRODUCTION

Obesity and behavioural risk factors of poor diet and physical inactivity contribute to the risk of developing chronic diseases such as type 2 diabetes, cardiovascular disease and some cancers (Ezzati *et al.*, 2004). In Australia, obesity and dietary factors combined contribute the greatest proportion of potentially preventable disease burden (Australian Institute of Health and Welfare, 2021). Tackling these modifiable factors is a significant preventive health priority for Australia and many other countries (World Health Organization, 2013; Commonwealth of Australia, 2021). Social marketing campaigns via mass media can raise public awareness, increase knowledge and positively influence relevant attitudes. Well-designed public health campaigns can also promote health-related behaviour change in target populations (Randolph and Viswanath, 2004; Noar, 2006) and can be cost-effective owing to their contribution to health care savings (Ananthapavan *et al.*, 2020, 2021). Beyond direct effects on the behaviour of exposed individuals, mass media campaigns that raise awareness of risk factors can benefit public health more broadly by increasing public support for policy changes that address those factors (Hilbert *et al.*, 2007; Huang *et al.*, 2015; Miller *et al.*, 2019; Nuss *et al.*, 2019; Murukutla *et al.*, 2020).

A challenge for all mass media campaigns is the need to compete for share of voice in an increasingly

complex and cluttered media environment (Randolph and Viswanath, 2004; Eagle *et al.*, 2005; Ha, 2017). Public health campaigns face the additional challenge of competing with commercial advertising of products and services that undermine their messages (Wakefield *et al.*, 2010). In the context of obesity prevention, commercial advertising may be considered to undermine public health campaign messages in two (potentially overlapping) ways. The first is through advertising for products that directly contribute to obesity. Exposure to unhealthy food and drink advertising influences product preferences and consumption and contributes to weight gain and obesity (Hoek and Gendall, 2006; Cairns *et al.*, 2013; Mills *et al.*, 2013; Boyland *et al.*, 2016; Powell *et al.*, 2017; Buchanan *et al.*, 2018). It is estimated that for every one obesity prevention advertisement viewed by US children, adolescents and adults, they viewed between 300 and 500 food and beverage advertisements between 2010 and 2011 (Kornfield *et al.*, 2015). As in other nations, energy-dense, nutrient-poor food and drinks are heavily marketed in Australian mass and social media, with sugary drinks being some of the most commonly featured and far outweighing alternative non-alcoholic drinks in terms of advertising expenditure (Kelly *et al.*, 2007; Boyland and Whalen, 2015; Smithers *et al.*, 2018; Haynes *et al.*, 2021). Advertising for unhealthy food and drinks is heavily concentrated around schools and is more heavily featured in areas of higher disadvantage (Vandevijvere *et al.*, 2018; Fagerberg *et al.*, 2019; Trapp *et al.*, 2021). This, along with evidence regarding advertising via other channels, suggests that children and adolescents of lower socioeconomic backgrounds may be disproportionately impacted by unhealthy food and drink marketing (Backholer *et al.*, 2021; Trapp *et al.*, 2021). Sugary drinks are consumed in excess by many Australians, with higher consumption among males, adolescents and young adults, and those of lower socioeconomic status (Miller *et al.*, 2019, 2020). Consumption of sugary drinks is linked with obesity, dental caries, type 2 diabetes and cancer (Hu, 2013; Malik *et al.*, 2013; Hodge *et al.*, 2018; Chazelas *et al.*, 2019), and the heavy marketing of sugary drinks and other unhealthy foods in Australia therefore presents a key and direct challenge to the success of obesity prevention media campaigns.

The second way in which commercial advertising may (indirectly) undermine obesity prevention campaigns is by confusing or diluting their messages. Given the difficulty of weight management and adopting dietary guidelines, individuals may be prompted to consider using commercial diet or weight loss solutions that offer simple recommendations (Katz, 2005). Commonly advertised commercial weight loss products and programmes include: kilojoule-controlled meals and meal plans; weight loss programmes; meal replacements and drinks or supplements marketed with purported appetite suppressant, detoxification or 'fat burning' qualities. Advertising for such products may therefore divert attention from the importance of a sustainable and affordable healthy lifestyle for chronic disease prevention in line with the best evidence disseminated by public health bodies (Katz, 2005; Harvey, 2021), thereby undermining obesity prevention campaigns. Weight loss claims associated with such programmes and accompanying products are often exaggerated and misleading (Khawandanah and Tewfik, 2016; Vakil *et al.*, 2017; Batsis *et al.*, 2021; Harvey, 2021), and may promise quick results without the need for changing lifestyle behaviours (Saper *et al.*, 2004; Katz, 2005; Harvey, 2021). In fact, fraudulent weight loss claims are some of the most commonly investigated by the United States Federal Trade Commission (Anderson, 2013), and the Australian Competition and Consumer Commission has also taken action against weight loss businesses in a number of high-profile cases (Australian Competition & Consumer Commission, 2012, 2014; Harvey, 2021). Many commercial products and services with associated weight loss claims do not result in clinically significant weight loss and resulting weight loss and lifestyle changes are not sustained (Tsai and Wadden, 2005; Mcevedy *et al.*, 2017). Worldwide, 42% of the adult population are trying to lose weight and 23% are trying to maintain weight, representing an enormous market for commercial weight loss or diet products or programmes (Santos *et al.*, 2017). However, consumers may find it difficult to appraise the potential effectiveness of the varied and complex array of advertised commercial products and services promising weight loss. Women are more likely than men to be trying to lose weight (Timperio *et al.*, 2000) and to use commercial diet plans and weight loss or meal replacement products (Julia *et al.*, 2014; Roy Morgan, 2015), and therefore may be more susceptible to the detrimental effects of exposure to commercial weight loss advertising than men.

Another category of commercial products that may be perceived to assist with weight management include 'diet' or artificially sweetened versions of sugary drinks. These products offer a reduced—or free from—sugar and kilojoule alternative and are commonly consumed in Australia, with nearly one in five Australian adults regularly consuming artificially sweetened soda (Miller *et al.*, 2020) and higher consumption observed among females than males (Pollard *et al.*, 2016). However, controversy exists over whether consumption of artificially sweetened drinks facilitates weight loss, and there is evidence that it independently contributes to metabolic abnormalities, cardiovascular risk, diabetes and mortality (Borges *et al.*, 2017; Malik *et al.*, 2019;

Meng *et al.*, 2021; Pan *et al.*, 2021; Zhang *et al.*, 2021). The marketing of artificially sweetened alternatives to sugary drinks may have a net detriment to public health by increasing consumption which may directly and/or indirectly impact chronic disease risk by distracting from the importance of making other positive changes to diet and activity promoted in public health campaigns.

It is well established that in Australia and other countries, commercial advertising expenditure for energy-dense nutrient-poor food and drinks far outweighs that for healthier products. However, to date, there have been no systematic comparisons between advertising expenditure on public health campaigns related to obesity prevention versus competing commercial product advertising. The Australian Government's National Preventive Health Strategy and National Obesity Strategy both recommend reducing the public's (especially children's) exposure to unhealthy food and drink marketing and promotion, as well as using evidence-based mass media campaigns to promote healthy eating and physical activity (Commonwealth of Australia, 2021, 2022). Understanding competing elements of the advertising environment in which obesity prevention campaigns have previously been delivered provides useful intelligence for informing future public health campaign planning as well as policy and advocacy to restrict unhealthy food and drink marketing. Therefore, the aim of this study is to quantify the competition from selected commercial advertising facing obesity prevention and related campaigns in Australian mass media. To do so, we compare expenditure on advertising for public health campaigns focussed on obesity prevention or related factors of healthy eating and/or physical activity with competing commercial advertising for (a) sugary drinks, (b) artificially sweetened drinks and (c) selected commercial diet or weight loss products and programmes.

METHODS

Advertising expenditure data

Nielsen Media Ad Intel service supplied estimated advertising expenditure in selected categories [non-alcoholic beverages, weight reduction services, diet foods, community/public service/appeals and government (state/federal)] for 2016, 2017 and 2018. Each data point summarized the total spend estimated for each advertisement by media channel, region, month and year, and was identified by advertiser, product name and a unique key number. The present study extends previous work by our group reporting advertising expenditure on non-alcoholic cold drinks, by comparing advertising expenditure in selected drink categories with commercial weight loss and public health advertising. The results of the previous work using this dataset and the details of Nielsen's monitoring methodology have been reported elsewhere (Haynes *et al.*, 2021). Inclusions for each media channel are summarized below.

Television. Advertising on free-to-air television in five metropolitan (Sydney, Melbourne, Brisbane, Adelaide and Perth) and six regional markets (Victoria, Western Australia, Queensland, New South Wales including Canberra, all of the Northern Territory and Tasmania) was monitored. Product appearances in programme content including in sports broadcasts or live product discussions were not measured.

Out-of-home. Out-of-home advertising expenditure in shopping centres, public transport vehicles and stations, street furniture, billboards, posters and mobile formats was monitored in all states and territories excluding Northern Territory. Note that this excluded advertising in sporting arenas and promotional activities in public spaces (e.g. giveaways).

Cinema. Advertising (excluding stills advertising) in cinemas across regional and metropolitan areas was monitored. Airtime logs were obtained from Val Morgan, the company responsible for advertising in virtually all Australian cinemas.

Radio. Advertising on the main metropolitan commercial radio stations in capital cities of Sydney, Melbourne, Brisbane, Adelaide and Perth was monitored. Estimates only included paid advertisements (including 'live reads') but did not include live discussions within programmes or sponsorship.

Digital. Advertising on more than 1900 high traffic websites (e.g. major news sites, weather, insurance, energy, file storage, sports, gaming, travel, banking, lifestyle, retail, digital streaming and review sites) was monitored, but excluded advertising on social media, smartphone apps, post-login (appearing after a user has logged in to a site) and programmatic advertising (programmed to appear in response to user's search history).

Newspapers. Display and classified advertisements ≥10 cm^2 in all national and capital city print newspapers, and display (but not classified) ads ≥40 cm^2 in major regional newspapers in all states and territories excluding South Australia and Western Australia were monitored. Some digital newspaper sites were captured in 'digital' content (above).

Magazines. Advertising in approximately 140 weekly and monthly magazines with high national circulation were included in estimates. Estimates also included newspaper insert magazines, but advertising inserts in magazines were excluded.

Data cleaning

Authors categorized data points into advertising for (a) sugary drinks, (b) artificially sweetened drinks, (c)

weight loss products and services (using advertiser and product names) and (d) public health campaigns (using advertiser names and ad key numbers where applicable). Table 1 summarizes advertising category definitions and included subcategories which were developed by the authors, including an accredited practicing dietitian (AM).

For commercial advertising categories (a), (b) and (c), a web search was conducted to confirm details of products and programmes in accordance with eligibility criteria and providers or product manufacturers were contacted to confirm where applicable. Non-alcoholic cold beverages (either ready-to-drink or with minimal preparation e.g. cordials or cold milk powders) with free sugars (added or naturally occurring e.g. 100% fruit juice) were classed as 'sugary drinks' (a). Sugary drinks included flavoured milks with added flavours and sugar and excluded plain dairy or plant-based milks (for a comparison of advertising expenditure for sugary drinks versus plain milk and plain water, see Haynes *et al.*, 2021). Beverages that contained artificial or non-nutritive intense sweeteners to replace sugar were classed as 'artificially sweetened drinks' (b). Commercial ads that promoted products across multiple categories (e.g. product 'range' that may have included both sugary and artificially sweetened drinks) were excluded from estimates (comprising 8.2% of advertising spend for non-alcoholic beverages). Full definitions of beverage subcategories and exclusions have been reported previously (Haynes *et al.*, 2021). Products or programmes with a diet and/or activity-related component marketed to aid weight loss were included in estimates of commercial weight loss products/services (c). This category included meal replacement drinks and drinks with 'detox' or 'slimming' properties (e.g. with appetite suppressant, or 'fat burning' claims), but did not include 'diet' drinks where the defining characteristic was that sugars were replaced with artificial or intense non-nutritive sweeteners. Non-diet or activity-related medical weight loss treatments (e.g. bariatric surgery, cosmetic procedures) were not included, and data were not available for weight loss supplements in tablet or capsule form.

Public health advertising (d) eligible for inclusion was non-commercial advertising for obesity prevention, including related factors of healthy eating and/or physical activity. Advertising that was directed at organizations or professionals (e.g. advertising of government grants for sporting clubs), rather than the public, was excluded. Public health advertising was coded as focussing on one or more of the eligible areas: obesity prevention (with an explicit weight-related focus or objective, e.g. raising awareness of the

Table 1: Advertiser categories, subcategories and exclusions

Advertiser categories and included subcategories	Excluded
(a)*Sugary drinks*	
Sugar-sweetened soft drinks	Coffee (instant, ground, beans, pods, for preparation of hot drinks)
Energy drinks	Tea (in bag or other format for preparation of hot drinks)
Sports drinks	Protein powders, supplements
100% fruit or vegetable juice	Infant/toddler formula
Fruit drinks (including cordial or other powder or liquid fruit flavouring to add to water)	Detox or weight loss drinks
Flavoured milk with added sugar (including iced coffee and powdered or liquid flavouring to add to milk)	Cooking ingredients (coconut milk, condensed milk)
Iced tea	Probiotic 'shots' in small serving size
Kombucha	Plain unflavoured and unsweetened dairy or plant alternative milk
Flavoured water	Plain unflavoured and unsweetened still or sparkling water
'Tonics' (e.g. 'Vitamin Water')	Product 'ranges' (spanning both sugary and artificial drinks or eligible and ineligible drinks), sponsorship
Non-alcoholic beer and wine	
(b)*Artificially sweetened drinks*	
Identical to 'sugary drinks', excluding 100% juice	
(c)*Commercial weight loss products and programmes*	
Diet meals/ meal plans	Bariatric surgery
Meal replacements (including drinks, shakes, soups, snacks)	Cosmetic procedures
Weight loss programmes or clinics	Weight loss supplements in capsule/tablet form
Weight loss or detox drinks	
(d)*Public health*	
Obesity prevention	Advertising targeting organizations/ professionals (not the public)
Healthy eating	Active community events, fundraisers, fun runs or races where primary focus was not to promote lifestyle change
Physical activity	

health impacts of overweight and obesity, or promoting behaviour change to achieve a healthy weight), healthy eating (encouraging eating consistent with the Australian Guide to Healthy Eating, e.g. by promoting fruit and vegetable intake, discouraging consumption of discretionary foods or sugary drinks, or raising awareness of front of pack labelling interventions such as Health Star Ratings) and/or physical activity (promoting increased physical activity, e.g. promoting uptake of organized sport or fitness activities, or increasing incidental activity such as via active transport). Some campaigns featured individual ads that fell across multiple areas (e.g. specific LiveLighter® campaign ads differentially focussed on obesity prevention, healthy eating and/or physical activity) (Morley *et al.*, 2019). Where the content of specific ads within a campaign could not be confirmed, all ads were coded as promoting all areas featured in the campaign.

The supplied data for public health and government advertisers were more coarsely labelled (e.g. data points were often labelled with a government department or organization name, rather than a specific campaign) than the commercial advertiser data (which were labelled with product names, enabling attribution of data points to specific products). Therefore, researchers were required to confirm details of campaign advertising strategy with representatives from relevant government departments and NGOs to attribute data points to specific campaigns and determine eligibility. However, due to limited resourcing (especially in view of the COVID-19 pandemic) and access to campaign history, full campaign details for seven large departments/organizations could not be determined. Therefore, the primary estimates of advertising presented in this paper represent activity attributable to public health campaigns that were confirmed as being eligible. We also present a conservative 'upper limit', which represents the sum of confirmed eligible public health ad spend plus the total spend attributable to departments/organizations which could not confirm details of campaign history but were suspected of having run an eligible campaign during the monitoring period.

Data analysis

Total advertising expenditure for all regions was combined into a single national estimate and aggregated by media channel, advertiser subcategory, month and year. The Consumer Price Index was used to adjust expenditure to 2018 Australian dollars to account for inflation and to show real changes over time (Australian Bureau of Statistics, 2018). Analyses were conducted in STATA 16 (Statacorp, 2019) and describe advertising expenditure (a) by advertiser category (sugary drinks, artificially sweetened drinks, commercial weight loss products and services, public health campaigns), (b) by media channels within advertiser categories and (c) by advertiser subcategories.

RESULTS

Advertising expenditure by category

Total advertising expenditure in 2018 dollars for sugary drinks over 2016–18 was AUD$129.5M, compared with a total of $23.3M for artificially sweetened alternatives, $121.9M for commercial weight loss products and services and $26.5M for obesity prevention, healthy eating and/or physical activity public health advertising (or $35M including unconfirmed expenditure). On average, monthly expenditure on public health advertising was outweighed by sugary drink advertising by 4.9 times and by commercial weight loss advertising by 4.6 times (Figure 1).

Advertising expenditure by media channel

As reported elsewhere (Haynes *et al.*, 2021), advertising expenditure for sugary drinks across the monitoring period was highest for television (monthly *m* = $1.6M, 45%), followed by out-of-home (monthly *m* = $1.2M, 35%, Table 2). Similarly, about half of advertising expenditure for artificially sweetened drinks was attributable to television (55%) followed by out-of-home (32%). In contrast, television made up a larger majority of expenditure for both commercial weight loss (72%) and public health (80%) advertising. Digital spend made up an additional 16% of commercial weight loss advertising expenditure, while the remainder of public health advertising spend was more evenly spread between other media channels (ranging 1–5% of total per channel).

Advertising expenditure by subcategory

Soft drinks, flavoured milks and energy drinks made up the largest proportion of advertising spend on sugary drinks across the monitoring period (26, 24 and 21% of sugary drink spend respectively, Table 3). The remainder was attributable to advertising for 'other' sugary drinks (iced tea, kombucha, tonics, fruit drinks), sports drinks and 100% fruit juice. In contrast, diet soft drinks alone made up 72% of artificially sweetened drinks advertising spend, with all other categories contributing between 3 and 14%.

The majority of commercial weight loss advertising was for weight loss programmes or clinics (66%), followed by weight loss or detox drinks (27%) and the small remaining percentage was for diet meals or meal replacements.

For public health advertising, the majority of expenditure was attributable to campaigns jointly promoting healthy eating, physical activity and obesity prevention (37%), or those solely promoting physical

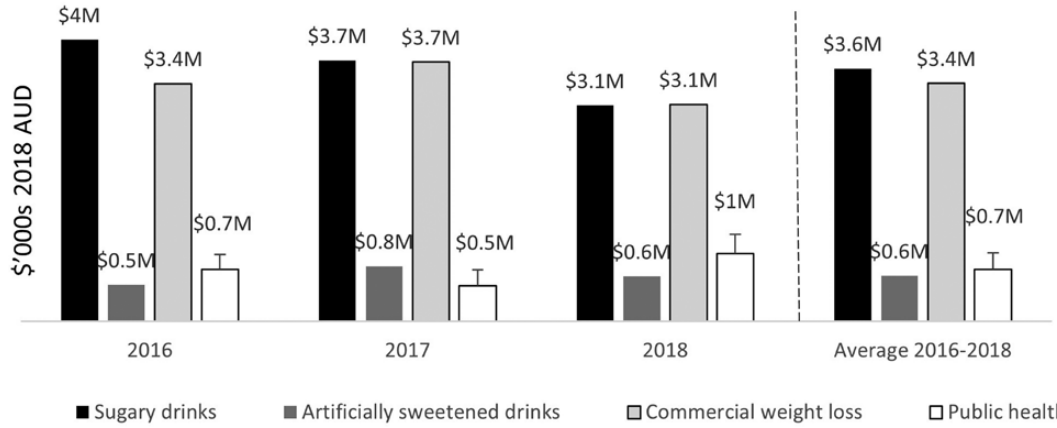

Fig. 1. Mean advertising expenditure per month by advertiser category. Error bars on 'public health' indicate additional expenditure for which eligibility was not confirmed.

Table 2: Mean monthly advertising expenditure by media channel across 2016–18

Media	Sugary drinks		Artificially sweetened drinks		Commercial weight loss		Public health	
Television	1616.2	45%	356.8	55%	2446.0	72%	590.2	80%
Out-of-home	1246.1	35%	203.7	32%	3.7	<1%	15.6	2%
Cinema	410.7	11%	11.2	2%	12.5	<1%	7.3	1%
Radio	144.7	4%	0.4	<1%	74.5	2%	79.5	1%
Digital	110.1	3%	15.5	2%	539.8	16%	15.6	2%
Newspapers	40.6	1%	7.3	1%	182.1	5%	34.7	5%
Magazines	27.6	1%	51.4	8%	126.9	4%	7.3	1%

Values are mean monthly $'000s in $AU2018 and column percentages are of the total monthly spend per advertiser category.

activity (36%). A further 20% was for campaigns with a joint focus on healthy eating and physical activity, while a small proportion was spent on campaigns for both healthy eating and obesity prevention or healthy eating only (5 and 2%).

DISCUSSION

This study demonstrates the vast expenditure on commercial advertising for products and services that may compete with public health messaging for obesity prevention and related factors of healthy eating and physical activity. Advertising expenditure on eligible public health campaigns was outweighed by sugary drink advertising—representing only one product that is associated with weight gain and chronic disease—by 4.9 times, and by commercial weight loss products and services by 4.6 times. Even in television advertising, which represented the dominant medium for public health advertising, sugary drink and commercial weight loss advertising expenditure vastly outweighed that for public health campaigns. For context, in 2018 the total expenditure on public health campaigns focussed on obesity prevention, healthy eating and/or physical activity equalled 46 cents per capita versus $3.24 per capita for competing commercial advertising on sugary or artificially sweetened drinks or weight loss.

The present study demonstrates the glaring discrepancy between expenditure on public health advertising for obesity prevention (and relatedly, healthy eating and physical activity) on the one hand; and a single product category (sugary drinks) that can contribute to weight gain on the other. Add advertising for energy-dense nutrient-poor foods into the mix and the dominance of unhealthy product advertising relative to public health campaigns is even more salient. Based on estimated advertising expenditure by major food and drink brands in the USA in 2017, sugary drinks made up just 13% of discretionary food and drink advertising, with fast food, snacks and confectionery making up the majority (Harris *et al.*, 2019). Similarly,

Table 3: Mean monthly advertising expenditure per advertiser category and subcategory across 2016–18

Advertising category	$'000s *m*/month	*sd*	Total (2016–18)	% category total
Sugary drinks	3596.0	1279.8	129 457.7	
Soft drinks	939.1	587.8	33 805.7	26%
Energy drinks	765.0	538.9	27 540.4	21%
Sports drinks	426.7	303.3	15 359.7	12%
Other drinks	511.1	443.5	18 401.2	14%
Flavoured milks	877.1	397.9	31 576.2	24%
100% fruit juice	77.1	94.3	2774.5	2%
Artificially sweetened drinks	646.2	359.6	23 265.0	
Soft drinks	466.9	307.7	16 807.1	72%
Energy drinks	18.8	102.5	676.5	3%
Sports drinks	36.5	75.9	1313.8	6%
Other drinks	93.7	92.0	3373.2	14%
Flavoured milks	30.4	110.1	1094.3	5%
Commercial weight loss	3385.5	973.0	121 879.8	
Diet meals/ meal plans	170.6	225.6	6141.6	5%
Meal replacements	43.6	133.4	1568.8	1%
Weight loss programmes or clinics	2247.1	570.6	80 895.0	66%
Weight loss or detox drinks	924.3	547.2	33 274.4	27%
Public health	736.6	516.4	26 518.0	
Healthy eating only	14.8	36.0	533.9	2%
Physical activity only	268.3	462.2	9658.7	36%
Obesity prevention only	—	—	—	—
Healthy eating + physical activity	146.2	168.9	5263.0	20%
Healthy eating + obesity prevention	36.4	63.4	1308.8	5%
Physical activity + obesity prevention	—	—	—	—
Healthy eating + physical activity + obesity prevention	270.9	276.6	9753.6	37%

Values are $'000s $AU2018 and percentages are of the total 2016–18 spend across all media per category.

sugary drinks made up 13% of ads for discretionary food and drink shown on Australian free-to-air TV in 2015 (with the majority of ads being for fast food and confectionery (Watson *et al.*, 2017). In total, Australian companies spend over $550 million per year on advertising food and non-alcoholic drinks and digital advertising for the five largest fast-food brands in Australia totalled over AU$40M between March 2020 and July 2021 (scaled down to a 12 month average in 2018 dollars (Macdonald, 2021; Public Health Association of Australia, 2021). These findings suggest that the true magnitude of competing advertising for unhealthy food and drink in Australia is likely to be much larger than our estimates focussed on drink advertising indicate.

Public health advertising for obesity prevention, healthy eating and/or physical activity was most strongly outweighed by competing commercial advertising for sugary and artificially sweetened drinks in the out-of-home media category. The heavy investment in out-of-home media for these drinks (and other unhealthy food and drink as evidenced in previous research, Trapp *et al.*, 2021) is likely to be a deliberate strategy to reach and influence consumers on the path to purchasing advertised products from nearby outlets. Advertising industry reports estimate that 93% of people are exposed to out-of-home advertising daily, and that it is more effective at driving brand awareness and desire for advertised products than other types of media (Outdoor Media Association, 2013). Previous analyses have shown that advertising for sugary drinks peaks in warmer months (late Spring and Summer), suggesting that that this advertising also capitalizes on seasonal patterns in typical consumption (Gearon *et al.*, 2021; Haynes *et al.*, 2021).

While expenditure on advertising for artificially sweetened drinks was lower than for all other categories, commercial weight loss and diet advertising expenditure still exceeded that for eligible public

health campaigns by nearly five times. Commercial weight loss advertising made up the majority of television and digital advertising ($2.4M and $0.5M per month on average) and may represent targeting of individuals at home where they may sign up for a weight loss programme or while searching online for information about weight loss. This category represents a wide range of products and services. While some may be effective at assisting with weight management and overall health, others may be ineffective or even harmful. For example, the majority of expenditure on commercial weight loss and diet advertising identified in this study (66%, representing $81M over 2016–18) was for programmes and clinics such as WW® (formerly Weight Watchers) and Jenny Craig®. Although these programmes can be effective at facilitating weight loss and are incorporated in public weight loss services in some countries (e.g. the UK's National Health Service), there is limited evidence for their impact on sustained weight loss (Tsai and Wadden, 2005; Mcevedy *et al.*, 2017). It was beyond the scope of the present study to evaluate the efficacy of each advertised weight loss or diet product/programme. With no consensus within the public health community on the role of many subtypes of commercial weight loss and diet products/programmes, the likelihood of consumers being confused or misled about effective approaches to behaviour change for healthy lifestyles is high. Further, such commercial weight loss or diet products and services may be out of financial reach for some parts of the population (Mcgill *et al.*, 2021). Heavy advertising for such products/programmes may contribute to the perception that specialized ultra-processed and packaged foods are required to lead a healthy lifestyle and for weight management, hindering other avenues to lifestyle change (Harvey, 2021). This is speculative, and future research could assess the impact of exposure to commercial weight loss advertising on subsequent beliefs and attitudes about behaviour and lifestyle change, given the high and increasing volume of advertising in this category (Pash, 2021).

Implications for obesity prevention

Australian State and Commonwealth governments are major funders of preventive health programmes and mass media campaigns. The vast magnitude of competing commercial advertising highlights the need for governments to act to ensure that advertising regulations are consistent with an ongoing commitment to improve public health and that they do not undermine the obesity prevention efforts that simultaneously receive government support. This is especially pertinent for out-of-home media, given that this medium comprises state-owned assets such as public transit vehicles and stations, and billboards on government-owned land, and where eligible public health advertising was most heavily outweighed by competing sugary drink advertising in this study. Unhealthy energy-dense, nutrient-poor food and drinks are heavily marketed in Australian media and industry self-regulatory codes are ineffective at protecting the public (Watson *et al.*, 2017). The findings of the present study support calls for further restrictions on advertising of products that directly contribute to weight gain and chronic disease risk in Australia. Another complementary strategy to rebalance the ratio of public health relative to competing advertising is to increase investment in high-reach multi-media obesity prevention and related public health campaigns. Careful formative planning, optimal media placement and robust evaluation to inform ongoing public health campaigns are also integral to maximize impact in this highly competitive environment (Grunseit *et al.*, 2016; Kite *et al.*, 2018). Monitoring of competing commercial advertising including its placement and timing may help to inform optimal placement and timing of public health advertising. One particular type of media campaign that may be useful to dilute the effects of competing commercial advertising is counter-advertising, which directly challenges competing commercial messages by highlighting industry profit motives, negative health consequences of products and/or misleading industry practices (Dorfman and Wallack, 1993; Palmedo *et al.*, 2017). Given the modest budgets for public health advertising relative to harmful industries, counter-advertising may be a useful strategy to complement traditional behaviour change-focussed public health campaigns in environments where unhealthy product advertising is underregulated (Dorfman and Wallack, 1993; Palmedo *et al.*, 2017). In the context of obesity prevention there is experimental evidence that counter-advertising can diminish the effect of unhealthy food advertising on preferences, beliefs and attitudes (Dixon *et al.*, 2020a); and reduce the susceptibility of young adults' brand attitudes and purchase intentions to the persuasive effects of elite sport sponsorship by fast food brands (Dixon *et al.*, 2020b). Counter-advertising or public education about claims associated with commercial diet or weight loss products and services (including artificially sweetened drinks) may be beneficial to empower the public to critically evaluate such product/programmes and selectively engage with those that are beneficial to their health. However, this strategy should be informed by sound evidence of the relative benefits and potential harms of such products and services and their role in public health, which is currently limited.

More broadly than promoting individual behaviour change, public health advertising (e.g. for obesity prevention, healthy eating and/or physical activity) can

promote positive attitudes toward government implementing policies to prevent chronic disease (Hilbert *et al.*, 2007; Huang *et al.*, 2015; Miller *et al.*, 2019; Nuss *et al.*, 2019; Murukutla *et al.*, 2020). Public support for government prevention policies can place them higher on the political agenda and facilitate implementation (Huang *et al.*, 2015). Policy-level changes that result in healthier, supportive environments can reach whole populations equitably, overcome systemic barriers, embed interventions and be more cost-effective than interventions focussed on individual behaviour change (Schmid *et al.*, 1995; Hawkes *et al.*, 2013, 2015). For example, exposure to an advertising campaign promoting awareness of the health harms of soft drinks in South Africa was associated with increased support for a sugary beverage tax, an evidence-based and cost-effective obesity prevention intervention (Murukutla *et al.*, 2020). Similar effects may be expected for physical activity promoting campaigns on public support for policies that facilitate physical activity such as through healthy and safe outdoor spaces and active transport infrastructure. To date, there is no evidence on the effect of exposure to competing commercial advertising on support for policy-level change. It is possible that advertising that places the onus on individuals to adopt commercial solutions for a healthy lifestyle minimizes support for government policies focussed on addressing upstream systemic factors, such as making the food and built environment conducive to health, although this is another question for future research.

Ultimately, without comprehensive regulation to restrict unhealthy product advertising, public health campaign budgets will always struggle to compete with the vast budgets of the commercial sector. In contrast, the lack of competition from direct-to-consumer tobacco advertising in Australia has provided a favourable context for the success of tobacco control mass media campaigns (Durkin *et al.*, 2012). Further regulation to limit unhealthy product advertising as has been achieved in other countries (World Cancer Research Fund International, 2021) should therefore be the priority for redressing the balance of messages related to obesity prevention, healthy eating and physical activity in Australian mass media. Doing may also help to reduce diet and weight inequities, given the greater impact of unhealthy food and drink marketing on those from disadvantaged backgrounds (Backholer *et al.*, 2021).

Strengths and limitations

Sugary drinks were selected to represent one example of competing commercial advertising because they are one of the most heavily marketed unhealthy food and drink products in Australian media, are consumed in excess by many Australians, and several public health campaigns from the study period discourage their consumption (Smithers *et al.*, 2018; Ananthapavan *et al.*, 2021; Browne *et al.*, 2021; Trapp *et al.*, 2021). However, an important limitation of the present study is that they are just one example of a product that contributes to weight gain, and thus represent a vast underestimate of the true scale of competing commercial advertising for energy-dense, nutrient-poor food and drink products. On the other hand, the commercial weight loss and diet category included in analyses consists of a range of different products and services with varied effects on weight management, and there is clearly a need for more research on the efficacy of these commercial options and their role in public health and obesity prevention. Similarly, estimates of commercial advertising related to fitness or physical activity but not directly to weight loss (e.g. fitness trackers, gyms) were not included, and it remains an open question whether this form of advertising helps or hinders public health messaging related to obesity prevention and/or that directly encourages physical activity.

This study included estimates of advertising expenditure across multiple mass media channels. However, a limitation is that the data provided poor coverage of digital advertising, including via social media and content that appears in response to users' online activity. These forms of digital marketing can target users and tailor relevant content with much more precision than advertising via traditional media and tend to be more engaging, immersive and interactive (Freeman *et al.*, 2014; Kelly *et al.*, 2021; Brooks *et al.*, 2022). Digital marketing offers potential for increasing reach and impact of health promotion campaigns on smaller budgets, but also attracts significant investment from competing commercial advertisers such as global food and drink companies (Dunlop *et al.*, 2016; Brooks *et al.*, 2022). Monitoring commercial marketing via new digital channels presents a challenge and a priority for future research in the area. The present estimates also did not include other highly visible forms of marketing such as sports sponsorship, which previous research has also shown to be dominated by unhealthy products (Dixon *et al.*, 2019). Such marketing may also divert expenditure from advertising via other channels that were included in our estimates (e.g. traditional TV advertising) during those events and programmes. Advertiser discounts offered for purchases of a larger number of advertising spots were applied by the media monitoring company. Other benefits and bonuses such as preferential placement of ads may also be afforded to larger purchasers. These among other factors mean that estimated advertising spend does not directly correlate with potential exposure: advertising spend by large volume advertisers is likely to provide better value for money and translate to wider exposure than a

proportionate spend by smaller advertisers (e.g. public health-oriented NGOs). Finally, a limitation specific to sugary drink advertising expenditure is that the supplied data also did not account for 'third party ads' in which sugary drinks may have a strong presence (e.g. advertising for fast food restaurants where a sugary drink brand is promoted alongside meal options).

CONCLUSION

This study quantified expenditure on public health advertising related to obesity prevention, healthy eating and/or physical activity in Australia in comparison to key categories of competing commercial advertising. We highlight the challenges for public health organizations operating in a highly competitive and cluttered media environment and underscore the need for strategies to maximize impact with smaller budgets than commercial advertisers. Further government regulation of unhealthy product marketing should be prioritized to protect and support public health, including by enhancing the impact of obesity prevention and related campaigns to promote behaviour change and garner support for health-promoting policies.

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PLOS MEDICINE

RESEARCH ARTICLE

Associations between trajectories of obesity prevalence in English primary school children and the UK soft drinks industry levy: An interrupted time series analysis of surveillance data

Nina T. Rogers[1]*, Steven Cummins[2], Hannah Forde[1,3], Catrin P. Jones[1], Oliver Mytton[1,4], Harry Rutter[5], Stephen J. Sharp[1], Dolly Theis[1], Martin White[1], Jean Adams[1]

1 MRC Epidemiology Unit, University of Cambridge School of Clinical Medicine, Institute of Metabolic Science, Cambridge, United Kingdom, **2** Population Health Innovation Lab, Department of Public Health, Environment and Society, London School of Hygiene and Tropical Medicine, London, United Kingdom, **3** Nuffield Department of Primary Care Health Sciences, University of Oxford, Oxford, United Kingdom, **4** Great Ormond Street Institute of Child Health, London, United Kingdom, **5** Department of Social and Policy Sciences, University of Bath, Bath, United Kingdom

* nina.rogers@mrc-epid.cam.ac.uk

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Abstract

Background

Sugar-sweetened beverages (SSBs) are the primary source of dietary added sugars in children, with high consumption commonly observed in more deprived areas where obesity prevalence is also highest. Associations between SSB consumption and obesity in children have been widely reported. In March 2016, a two-tier soft drinks industry levy (SDIL) on drinks manufacturers to encourage reformulation of SSBs in the United Kingdom was announced and then implemented in April 2018. We examined trajectories in the prevalence of obesity at ages 4 to 5 years and 10 to 11 years, 19 months after the implementation of SDIL, overall and by sex and deprivation.

Methods and findings

Data were from the National Child Measurement Programme and included annual repeat cross-sectional measurement of over 1 million children in reception (4 to 5 years old) and year 6 (10 to 11 years old) in state-maintained English primary schools. Interrupted time series (ITS) analysis of monthly obesity prevalence data from September 2013 to November 2019 was used to estimate absolute and relative changes in obesity prevalence compared to a counterfactual (adjusted for temporal variations in obesity prevalence) estimated from the trend prior to SDIL announcement. Differences between observed and counterfactual estimates were examined in November 2019 by age (reception or year 6) and additionally by sex and deprivation quintile. In year 6 girls, there was an overall absolute reduction in obesity prevalence (defined as >95th centile on the UK90 growth charts) of 1.6 percentage

information/publications/statistical/national-child-measurement-programme) for researchers who meet the criteria for access to confidential data.

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Abbreviations: AIC, Akaike information criterion; BMI, body mass index; CI, confidence interva; GLS, generalised least squares; IMD, index of multiple deprivation; ITS, interrupted time series; NCMP, National Child Measurement Programme; PP, percentage point; SSB, sugar-sweetened beverage; SDIL, soft drinks industry levy.

points (PPs) (95% confidence interval (CI): 1.1, 2.1), with greatest reductions in the two most deprived quintiles (e.g., there was an absolute reduction of 2.4 PP (95% CI: 1.6, 3.2) in prevalence of obesity in the most deprived quintile). In year 6 boys, there was no change in obesity prevalence, except in the least deprived quintile where there was a 1.6-PP (95% CI: 0.7, 2.5) absolute increase. In reception children, relative to the counterfactual, there were no overall changes in obesity prevalence in boys (0.5 PP (95% CI: 1.0, −0.1)) or girls (0.2 PP (95% CI: 0.8, −0.3)). This study is limited by use of index of multiple deprivation of the school attended to assess individual socioeconomic disadvantage. ITS analyses are vulnerable to unidentified cointerventions and time-varying confounding, neither of which we can rule out.

Conclusions

Our results suggest that the SDIL was associated with decreased prevalence of obesity in year 6 girls, with the greatest differences in those living in the most deprived areas. Additional strategies beyond SSB taxation will be needed to reduce obesity prevalence overall, and particularly in older boys and younger children.

Trial registration

ISRCTN18042742.

Author summary

Why was this study done?

- In England, childhood obesity rates are high with around 10% of reception age children (4/5 years) and 20% of children in year 6 (10/11 years) recorded as living with obesity in 2020.
- Children who are obese are more likely to suffer from serious health problems including high blood pressure, type 2 diabetes, and depression in childhood and in later life.
- In March 2016, to tackle childhood obesity, the UK government announced there would be a soft drinks industry levy (SDIL) on manufacturers of soft drinks to incentivize them to reduce the sugar content of drinks.

What did the researchers do and find?

- We tracked changes in the levels of obesity in children in England from reception (ages 4/5 years) and year 6 (ages 10/11 years) over time between 2014 and 2020. This analysis involved comparing obesity levels 19 months following the SDIL with predicted obesity levels had the SDIL not happened according to gender of the child and school's area level of deprivation.
- The UK SDIL was associated with an 8% relative reduction in obesity levels in girls aged 10/11 years, equivalent to prevention of 5,234 cases of obesity per year in girls aged 10/11 years, alone. Reductions were greatest in girls whose school was in the 40% most deprived areas.
- No associations were found between the SDIL and changes in obesity levels in boys aged 10/11 years or younger children aged 4/5.

What do these findings mean?

- Our findings suggest that the UK SDIL led to positive health impacts in the form of reduced obesity levels in girls aged 10/11 years.
- Further strategies are needed to reduce obesity prevalence in primary school children overall, and particularly in older boys and younger children.

Introduction

There is strong evidence that consumption of sugar-sweetened beverages (SSBs) increases the risk of serious diseases including type 2 diabetes, cardiovascular disease, dental caries, and obesity [1–3]. Children and adolescents in the United Kingdom are particularly high consumers of added sugars [4] with consumption typically peaking at approximately 70 g/day in late adolescence, equivalent to over twice the recommended maximum intake of 30 g [5]. SSBs are the primary source of free sugar in the diets of children and are associated with weight gain, obesity, and fatness in children [6–8]. Demographic patterns of SSB and added sugar consumption mirror each other with highest consumption in older children [5,9], boys [9,10], and children from lower socioeconomic groups [11–13]. Recently born cohorts of children are much more likely to have obesity than children from older cohorts such that 10-year-olds born after the 1980s are 2 to 3 times more likely to develop obesity than those born before the 1980s [14]. The persistence of obesity from childhood into adulthood [15] and its acute and chronic negative physical [16–19] and mental [16,20] health consequences in children has led to governments around the world focusing on preventive strategies to reduce obesity in early life.

The World Health Organization recommends taxes on SSBs to reduce consumption of added sugars to improve health [21]. Over 50 jurisdictions have implemented taxes on soft drinks, although they differ in terms of how much tax is passed through to the consumer, the types of soft drink targeted and the structure of the tax (including banded structure [22] and taxes levied in terms of volume sold [23] or as a proportion of the price [24]). In March 2016, the UK government proposed a number of strategies, including a soft drinks industry levy (SDIL) on manufacturers, importers, and bottlers of SSBs, to reduce prevalence of obesity in childhood [25]. The two-tier SDIL, implemented in April 2018, differed from most other tax structures in that it was designed to incentivise manufacturers to reformulate higher sugar soft drinks to move them to a lower tax tier. Manufacturers and importers were subject to a charge of £0.24/litre on soft drinks containing $\geq$8 g of sugar per 100 ml, £0.18/litre on soft drinks containing between $\geq$5 to <8 g of sugar per 100 ml, and no levy on drinks containing <5 g sugar per 100 ml [26]. Levy exempt drinks include milk, milk-based drinks, 100% fruit juice, and powders used to make drinks. As part of the broader health strategy for young people, the UK government indicated they would use revenues raised through the SDIL to fund physical education in schools and breakfast and after-school clubs [27].

Evidence suggests that the UK SDIL led to substantial reformulation of the UK soft drinks market. The percentage of drinks containing >5 g sugar/100 ml fell from 49% to just 15% between September 2015 and February 2019, with reformulation accelerating after announcement of the UK SDIL [28]. Overall, the UK SDIL was associated with a reduction in sugar purchased from soft drinks [29]. While the price of soft drinks increased following implementation of the SDIL, the levy was only partially passed on to the consumer. For example, in drinks containing between $\geq$5 to <8 g of sugar per 100 ml, approximately one-third of the levy was passed on [28]. A number of modelling studies [30–33] have predicted that the

introduction of SSB taxes would lead to a modest reduction in obesity in children and adults at the population level, but no study to date has used empirical data to examine whether the response of the SSB industry to the UK SDIL was associated with a subsequent change in the prevalence of childhood obesity. A few studies have used empirical data to estimate associations between SSB taxes and weight-related outcomes in children and adolescents and have either shown no overall association [23,34–36] or small to modest associations in specific subgroups such as low-income households [36] children with higher body mass indices (BMIs) [36,37] or in adolescent girls but not boys [38]. Different findings from these discrete studies may be related to use of different outcome measures (in particular, one study relied on subjective measures of self-reported weight [34]), differences in change in SSB prices achieved by taxes (some were associated with small average increases in prices of SSB (<5%) [34,35]) or differences in substitutions to high-calorie untaxed food [23] and drinks [23,35].

In this study, we use cross-sectional data on monthly prevalence of objectively assessed obesity in children when they enter (reception class; ages 4 to 5) and exit (year 6; ages 10 to 11) English primary schools to examine whether 19 months following the implementation of the UK SDIL there were changes in the trajectory of prevalence of obesity (1) overall and (2) by sex and deprivation.

Methods

The study was registered (ISRCTN18042742) and the study protocol published [39]. This study is reported as per the REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement (S1 Checklist).

Data source

We used population level data from the National Child Measurement Programme (NCMP). This surveillance programme began in 2006 and measures the height and weight of approximately 1 million children from English state-maintained primary schools in reception (ages 4 to 5 years) and year 6 (ages 10 to 11 years) annually, with the aim of monitoring national rates of overweight and obesity in children. Local authorities oversee the data collection, and letters are sent to the parents of eligible children where they are informed about why the data are collected and how these are stored. There is also an opportunity to opt out of measurement. Approximately 99% of eligible schools (approximately 17,000 schools) take part each year and individual response rates are high with over 90% of eligible pupils taking part [40].

Surveillance data provided by NCMP include prevalence of children with overweight or obesity by school class (reception or year 6), sex (male or female), school year (e.g., 2013/14), month of measurement, and the index of multiple deprivation (IMD) quintile of the location of the primary school that the child attends. The NCMP measures the height and weight of children in England throughout the academic school year (September to July); hence, there was no available data for the month of August when the long summer holiday takes place. IMD scores are commonly used in England as measures of multiple deprivation by considering seven distinct domains including income, employment, education, barriers to housing, health and disability, crime, and living environment [41]. The BMI thresholds used to derive overweight and obesity prevalence values were based on the 85th and 95th centiles, respectively, of a reference sample of measures taken in the UK in 1990 taking account of height, weight, sex, and age, reflecting the definitions used by Public Health England for population surveillance [42]. The study period was initially planned to end 2 years following the implementation of SDIL, but follow-up was curtailed in November 2019

(4 months prior to the proposed end date) to avoid any influence of potential household storing of food and drink in preparation for (i) the UK leaving the European Union (December 2019) and (ii) national lockdown because of the COVID-19 pandemic (March 2020) [43] to avoid contamination with documented changes in weight status occurring in the pandemic [44].

Statistical analysis

Interrupted time series (ITS) analyses were conducted to assess obesity prevalence in relation to the UK SDIL in children attending primary school reception or year 6 classes, overall and by sex and IMD quintile. The ITS used monthly data from September 2013 (study month 1) until November 2019 (study month 69), including the months of the SDIL announcement (March 2016; study month 29) and implementation (April 2018; study month 52).

Generalised least squares (GLS) models were used. Autocorrelation in the time series was examined visually using plots of autocorrelation and partial autocorrelation and statistically using Durbin–Watson tests; an autocorrelation-moving average (ARIMA) correlation structure was used, with the order (p) and moving average (q) parameters chosen to minimise the Akaike information criterion (AIC) in each model. School holidays are reported to influence weight-related outcomes in school children [45]. To take account of this and other key events in the academic calendar year that might impact weight, we used calendar months as a proxy. Following a standard data-driven approach, to identify which calendar months might predict significant changes in obesity prevalence, we ran a series of GLS models in which a single calendar month was added to the equation. After all, calendar months were tested individually; models were finalised by including all the months that showed significant changes in obesity prevalence. Adding all months as dummy variables was avoided to restrict the number of variables to those that were informative, to reduce error, and to increase the precision of our estimates. The months of September, October, June, and February were significant for reception class children, and September and July were significant for year 6 children. Models for year 6 and reception age children were examined separately because reception age children in England typically start school full time, a few weeks after older children have returned. Model specifications for year 6 and reception class children are included (S1 Text). Counterfactual scenarios were estimated based on pre-announcement trends (S1 Fig). Absolute and relative differences in prevalence of obesity between observed and counterfactual values were estimated at month 69 (November 2019). Confidence intervals were calculated from standard errors estimated using the delta method [46]. All statistical analyses were performed in R version 4.1.0.

Sensitivity analysis 1: Inclusion of two alternative interruption points

The main analysis included a counterfactual based on the pre-announcement trend (i.e., a scenario where neither the announcement nor implementation happened); however, previous research suggests that reformulation of drinks began some months after the announcement of SDIL but before implementation [28]. Therefore, as well as capturing the earliest possible time when reformulation could come into effect, in sensitivity analyses (S1 Fig), we used two alternative interruption points. First (sensitivity analysis 1a), we used a counterfactual based on the trend from September 2013 to November 2016 (equivalent to 8 months post-announcement and the point at which reformulation increased rapidly) [28]. Second (sensitivity analysis 1b), we used a counterfactual based on the pre-implementation trend, i.e., from September 2013 to April 2018.

Sensitivity analysis 2: Combining overweight and obesity prevalence

In addition to examining prevalence of obesity, the main analysis was repeated and broadened to examine trajectories of excess weight prevalence, in relation to the SDIL, using monthly measures of overweight in addition to obesity.

Results

Table 1 summarises the mean obesity prevalence in the study period (i) before the SDIL announcement and (ii) after the SDIL announcement, in primary school children in reception and year 6, overall and by sex and IMD quintile. Highest levels of obesity were observed in the most deprived areas regardless of age and sex; pupils in schools from the most deprived IMD quintiles had nearly twice the prevalence of obesity as those in the least deprived IMD quintiles.

Changes in obesity prevalence in relation to SDIL

Unless stated otherwise below, all estimates of changes in prevalence of obesity are based on values from November 2019 with respect to the counterfactual scenario of no SDIL announcement or implementation having occurred.

Across all year 6 children, there was a 0.8-percentage point (PP) (95% confidence interval (CI): 0.3, 1.3) absolute reduction or 3.6% (95% CI: 1.2, 5.9) relative reduction in obesity prevalence compared to the counterfactual (see Table 2). Year 6 children in schools from the most deprived IMD quintiles (IMD1 and 2) had the greatest (relative) reductions in obesity prevalence of 4.1% (95% CI: 1.8, 6.3) and 5.5% (95% CI: 3.3, 7.7), respectively; however, large differences between year 6 girls and boys were observed. In year 6 girls, there was an overall relative

Table 1. Mean obesity prevalence (standard deviation) in the pre- and post-announcement periods of the UK SDIL, by school class, sex, and IMD quintiles.

Mean (standard deviation) obesity prevalence in primary school children in reception[1] and year 6[2] class						
	Total population		Boys		Girls	
	Pre-announcement[3]	Post-announcement[4]	Pre-announcement	Post-announcement	Pre-announcement	Post-announcement
School class: Reception[1]						
All IMD	9.5(0.9)	9.8(0.9)	9.8(1.9)	10.0(2.2)	9.0(1.9)	9.4(2.1)
IMD 1 (most deprived)	11.9(0.6)	12.5(0.8)	12.2(0.6)	12.9(0.8)	11.5(0.7)	12.2(1.0)
IMD 2	10.6(0.8)	11.0(0.8)	11.1(0.8)	11.4(1.0)	10.1(1.0)	10.6(0.9)
IMD 3	9.1(0.7)	9.5(1.0)	9.4(0.6)	9.8(1.0)	8.8(0.9)	9.3(1.1)
IMD 4	8.3(0.9)	8.5(0.7)	8.8(1.1)	8.6(0.7)	7.8(0.9)	8.3(1.0)
IMD 5 (least deprived)	7.0(0.8)	7.1(0.8)	7.4(0.8)	7.3(0.8)	6.8(1.1)	6.7(0.9)
School class: Year 6[2]						
All IMD	19.2(0.5)	20.1(0.6)	20.8(3.9)	22.1(4.6)	17.3(3.8)	17.9(4.0)
IMD 1	24.3(1.0)	26.0(0.7)	26.1(1.1)	28.4(1.0)	22.5 (1.1)	23.5(0.8)
IMD 2	21.8(0.7)	23.1(0.7)	23.4(0.9)	25.4(1.1)	20.1(0.9)	20.7(0.8)
IMD 3	19.0(0.6)	19.7(0.9)	20.7(0.8)	21.7(1.3)	17.2(0.9)	17.6(0.8)
IMD 4	16.6(0.7)	17.2(0.8)	18.3(0.8)	19.2(1.0)	14.8(0.9)	15.2(0.9)
IMD 5	13.8(0.7)	14.2(0.6)	15.4(1.0)	15.9(0.9)	12.2(0.7)	12.3(0.7)

[1]Reception class–ages 4/5.

[2]Year 6 class–ages 10/11.

[3]Pre-announcement period = September 2013–March 2016.

[4]Post-announcement period = April 2016–November 2019.

IMD, index of multiple deprivation; SDIL, soft drinks industry levy.

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Table 2. Absolute and relative changes in prevalence of obesity (95% CIs), compared to the counterfactual[1], in reception and year 6 boys and girls, by IMD at 19 months post-implementation of the UK SDIL.

	Total population		Boys		Girls	
Interruption–SDIL announcement	**PP change**	**Relative change (%)**	**PP change**	**Relative change (%)**	**PP change**	**Relative change (%)**
Reception						
All IMD	0.3(0.9, −0.3)	3.0(−3.1, 9.1)	0.5(1.0, −0.1)	4.5(−1.0, 10.0)	0.2(0.8, −0.3)	2.4(−3.6, 8.4)
IMD 1 (most deprived)	−0.5 (0.1, −1.1)	−3.9(−8.4, 0.6)	−0.4(0.2, −0.9)	−2.6(−6.7, 1.4)	−0.6(0.1, −1.2)	−4.3(−9.0, 0.4)
IMD 2	**0.7(1.2, 0.2)**	**6.7(2.0, 11.4)**	**1.2(2.1, 0.4)**	**11.1(3.3, 18.9)**	0.3(0.9, −0.3)	2.6(−3.2, 8.4)
IMD 3	**0.9(1.7, 0.2)**	**9.7(1.6, 17.9)**	0.7(1.7, −0.3)	7.3(−2.7, 17.4)	**1.2(1.8, 0.5)**	**13.0(5.4, 20.5)**
IMD 4	**0.5(1.0, 0.1)**	**6.3(1.0, 11.6)**	0.5(1.1, −0.2)	5.4(−2.2, 12.9)	0.3(0.6, −0.1)	3.5(−0.6, 7.6)
IMD 5 (least deprived)	**0.6(1.1, 0.1)**	**10.0(2.2, 17.9)**	**0.6(1.1, 0.1)**	**9.7(2.0, 17.4)**	**0.6(1.2, 0.003)**	**10.8(0.1, 21.5)**
Year 6						
All IMD	**−0.8(−0.3, −1.3)**	**−3.6(−5.9, −1.2)**	−0.04(0.6, −0.6)	−0.2(−2.7, 2.4)	**−1.6 (−1.1, −2.1)**	**−8.0 (−10.5, −5.4)**
IMD 1	**−1.1(−0.5, −1.8)**	**−4.1(−6.3, −1.8)**	0.2(0.9, −0.5)	0.6(−1.8, 3.0)	**−2.4(−1.6, −3.2)**	**−9.0(−12.1, −5.9)**
IMD 2	**−1.4(−0.8, −1.9)**	**−5.5(−7.7, −3.3)**	**−0.9(−0.1, −1.7)**	**−3.3(−6.2, −0.4)**	**−2.5(−2.1, −2.9)**	**−11.0(−12.7, −9.2)**
IMD 3	0.01(0.6, −0.6)	0.04(−3.0, 3.1)	1.0(2.4, −0.5)	4.5(−2.1, 11.1)	−0.5(0.2, −1.2)	−2.8(−6.5, 0.9)
IMD 4	0.2(0.8, −0.4)	1.1(−2.1, 4.4)	0.3(1.0, −0.5)	1.3(−2.3, 4.8)	0.2(0.9, −0.5)	1.2(−3.40, 5.9)
IMD 5	0.3(0.8, −0.3)	1.9(−1.8, 5.6)	**1.6(2.5, 0.7)**	**10.1(4.3, 15.9)**	**−0.9(−0.3, −1.5)**	**−7.0(−11.6, −2.3)**

[1]Estimated from pre-announcement trends.

CI, confidence interval; IMD, index of multiple deprivation; PP, percentage point; SDIL, soft drinks industry levy.

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reduction in obesity prevalence of 8.0% (95% CI: 5.4, 10.5). Analysis by IMD revealed greatest reductions in the two most deprived IMD quintiles (1 and 2) of 9.0% (95% CI: 5.9, 12.1) and 11.0% (95% CI: 9.2, 12.7), respectively, where a clear break in trend was observed graphically some months following the SDIL implementation (Fig 1). In year 6 boys, there was no overall change in obesity prevalence and no obvious pattern in changes in prevalence by IMD quintile, although there was a large relative increase in obesity prevalence of 10.1% (95% CI: 4.3, 15.9) in the least deprived IMD quintile and a small reduction in prevalence of obesity in IMD2 of 3.30% (95% CI: 0.4, 6.2) (Fig 2).

In reception children, compared to the counterfactual, there was no absolute change in obesity prevalence overall in girls (0.2 PP (95% CI: 0.8, −0.3)) and boys (0.5 PP (95% CI: 1.0, −0.1)). Examination by IMD and sex showed a consistent increase in prevalence of obesity, compared to the counterfactual, in the least deprived IMD groups in both girls (0.6 PP (95% CI: 1.2, 0.003)) (Fig 3) and boys (0.6 PP (95% CI: 1.1, 0.1)) (Fig 4) in reception class.

When the interruption point was changed to December 2016 (8 months post-SDIL announcement, the point at which reformulation began, sensitivity analysis 1a), changes in obesity prevalence were consistent with the main findings, with reductions in obesity prevalence evident in year 6 children, specifically girls from schools in the most deprived areas (IMD 1 and 2) (S1 Table), and increases in obesity prevalence in year 6 boys from the least deprived areas (IMD 4 and 5). When the interruption point was changed to April 2018 (month of SDIL implementation, sensitivity analysis 1b, S2 Table) findings varied from the main analysis, with an overall absolute increase in the prevalence of obesity in reception age children by 0.7 PP (95% CI: 0.1, 1.3). Compared to the counterfactual, there were few significant changes in obesity prevalence in the different year 6 groups, although reductions (e.g., 3.8% (95% CI 5.7, 2.0) in year 6 girls from IMD 2) and increases (e.g., 3.8% (95% CI 0.2, 7.4) in boys in IMD4) were observed in some groups.

Changes in prevalence of excess weight (overweight or obesity) in relation to the UK SDIL were comparable to the main findings on changes in trends in prevalence of obesity,

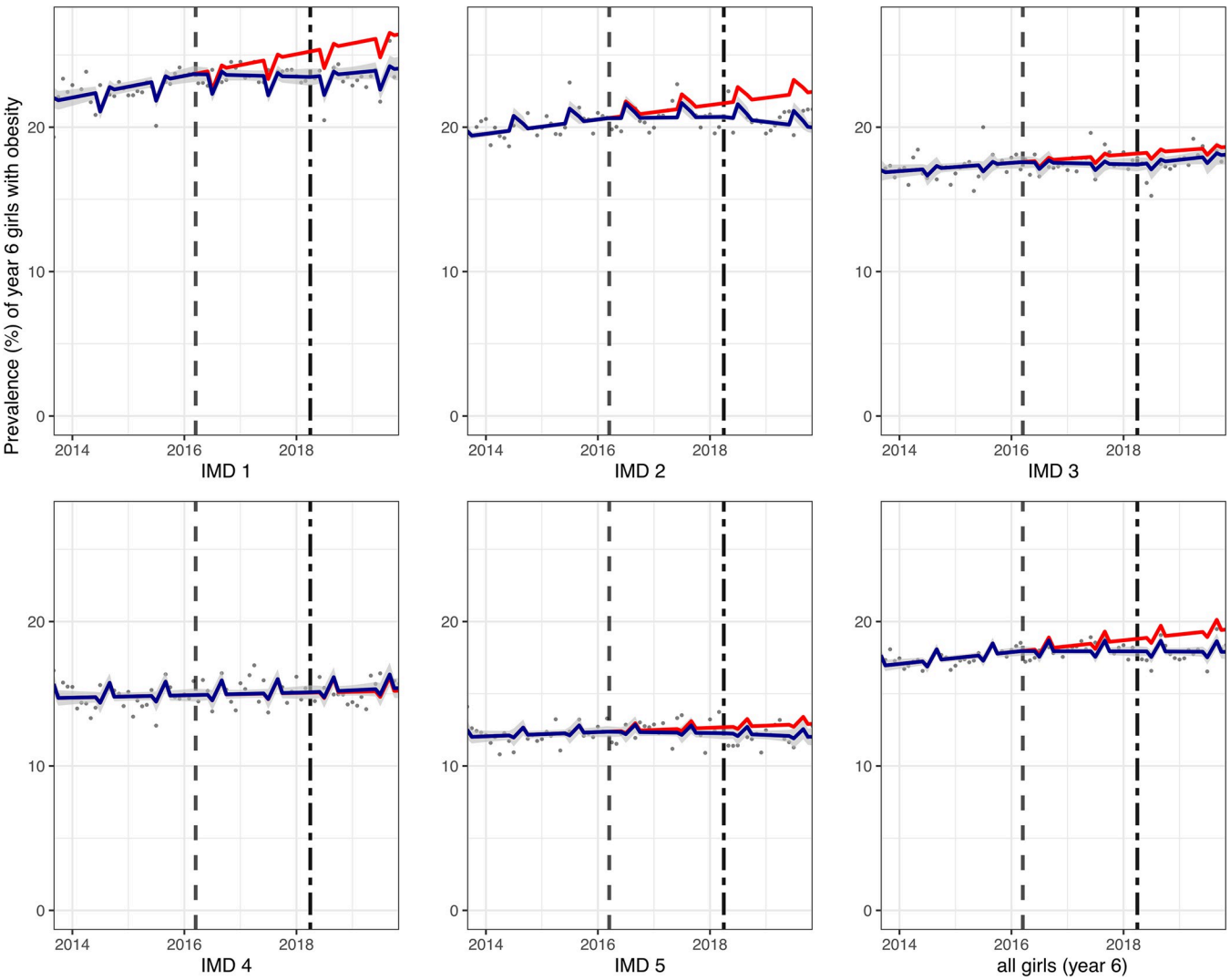

Fig 1. Prevalence (%) of obesity in year 6 girls (aged 10/11) between September 2013 and November 2019. Observed and modelled prevalence of obesity is shown by IMD quintile and overall. Dark blue points show observed data and dark blue lines (with grey shadows) shows modelled data (and 95% CIs) of obesity prevalence. The red line indicates the counterfactual line based on the pre-SDIL announcement trend (assuming the announcement and implementation had not occurred). The first and second dashed vertical lines indicate the announcement and implementation of the SDIL, respectively. CI, confidence interval; IMD, index of multiple deprivation; SDIL, soft drinks industry levy.

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with greatest reductions in excess weight observed in girls from schools in IMD quintiles 1 and 2 and no change in prevalence of excess weight overall in year 6 boys or reception age children (S3 Table). However, compared to the counterfactual scenario of no announcement or implementation, there was an observed absolute reduction in excess weight of reception age girls from the most deprived IMD (1) of 1.6 PP (95% CI 1.1, 2.1).

Discussion

Summary of findings

This is the first study that we are aware of that uses empirical data to examine changes in childhood obesity prevalence in England in relation to the UK SDIL. After accounting for prior trends in obesity, there was a 0.8-PP absolute reduction in year 6 children living

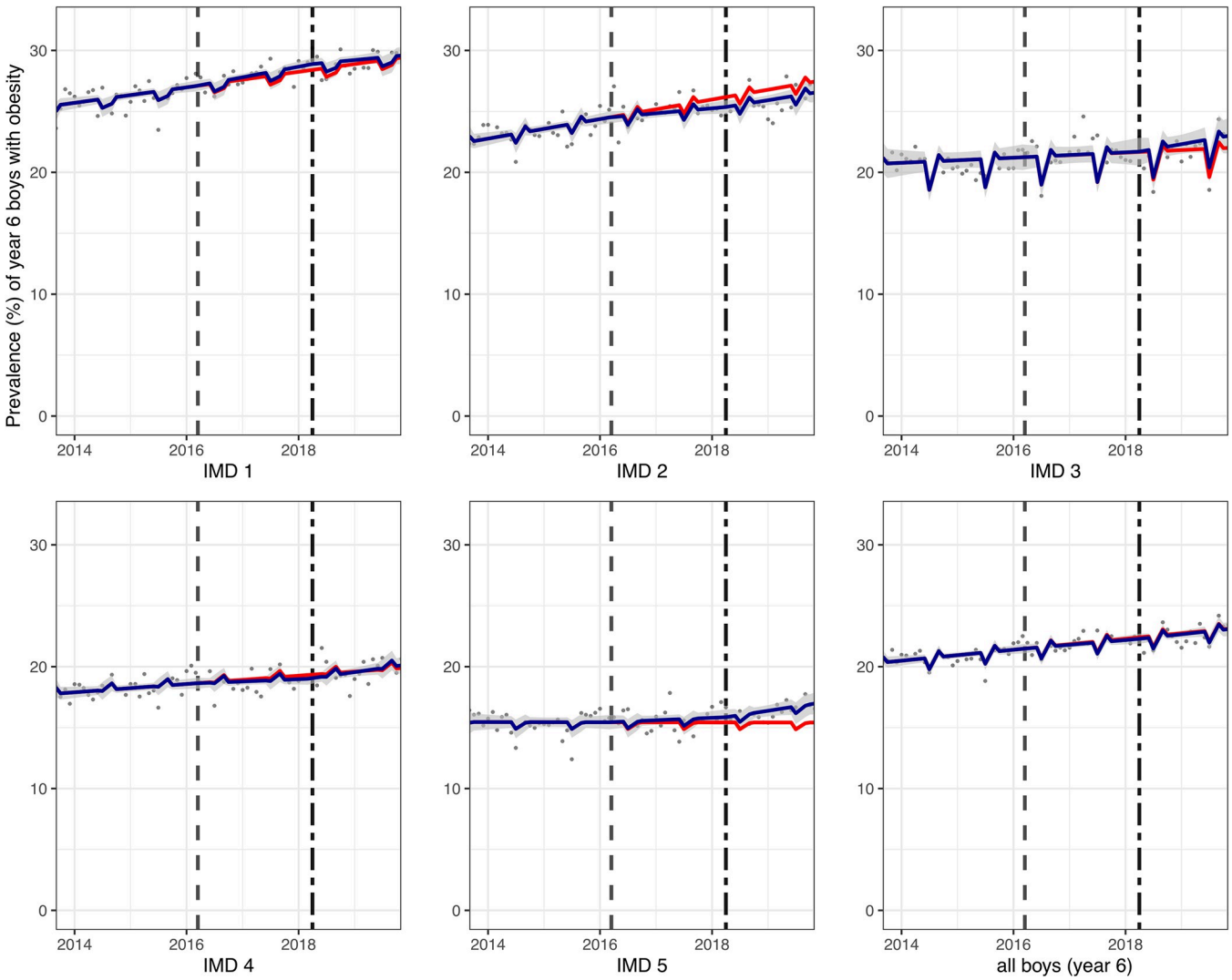

Fig 2. Prevalence (%) of obesity in year 6 boys (aged 10/11) between September 2013 and November 2019. Observed and modelled prevalence of obesity is shown by IMD quintile and overall. Dark blue points show observed data and dark blue lines (with grey shadows) shows modelled data (and 95% CIs) of obesity prevalence. The red line indicates the counterfactual line based on the pre-SDIL announcement trend (assuming the announcement and implementation had not occurred. The first and second dashed vertical lines indicate the announcement and implementation of the SDIL, respectively. NB: The scales used in Figs 2–4 differ to maximise resolution of the image. CI, confidence interval; IMD, index of multiple deprivation; SDIL, soft drinks industry levy.

https://doi.org/10.1371/journal.pmed.1004160.g002

with obesity, 19 months after the implementation of the SDIL. These reductions in year 6 children were predominantly driven by changes in girls, where there was a 1.6-PP absolute or 8.0% relative reduction in obesity prevalence. Assuming, based on our 2019 data, that there are 337,658 year 6 girls in England (of whom 18.4% have obesity), this reduction is equivalent to 5,234 averted cases of obesity in year 6 girls. Relative to the counterfactual, no overall change was observed in year 6 boys. We observed that for year 6 girls, reductions in obesity were greatest in the 40% most deprived IMD areas, with a 2.4-PP absolute or 9.0% relative reduction in the most deprived IMD quintile. Overall, the prevalence of obesity in reception class children was unchanged, compared to the counterfactual.

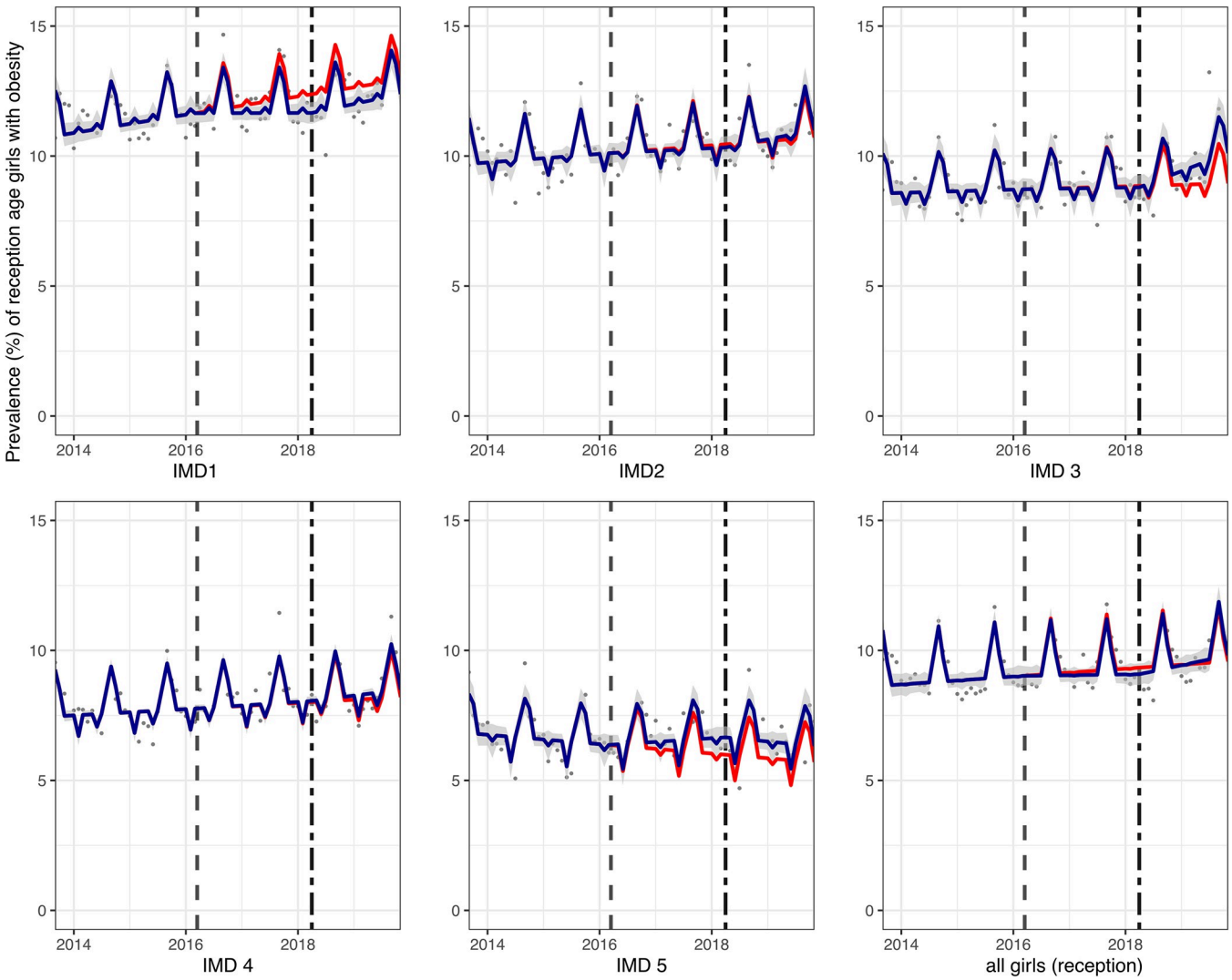

Fig 3. Prevalence (%) of obesity in girls in reception class (aged 4/5) between September 2013 and November 2019. Observed and modelled prevalence of obesity is shown by IMD quintile and overall. Dark blue points show observed data and dark blue lines (with grey shadows) shows modelled data (and 95% CIs) of obesity prevalence. The red line indicates the counterfactual line based on the pre-SDIL announcement trends (assuming the announcement and implementation had not occurred). The first and second dashed vertical lines indicate the announcement and implementation of the SDIL, respectively. CI, confidence interval; IMD, index of multiple deprivation; SDIL, soft drinks industry levy.

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Comparison with other studies and implications

In this section, we draw on evidence from other studies and compare our findings with them, while also providing some potential explanations for our results and their implications.

First, our findings are plausible since associations between SSB consumption and risk of obesity are well described in the literature [6–8]. Furthermore, a relationship between the UK SDIL and an overall reduction in sugar purchased from soft drinks across the population has previously been reported [29]. Several modelling studies have also predicted that SSB taxes are likely to be most effective at targeting sugar intake in children and younger adults [47,48].

Second, the magnitude and pattern of associations in our results are consistent with recent findings from Mexico that report a modest reduction in overweight or obesity prevalence in adolescent girls (aged 10 to 18) with a 1.3-PP absolute decrease 2 years after a 10% SSB price

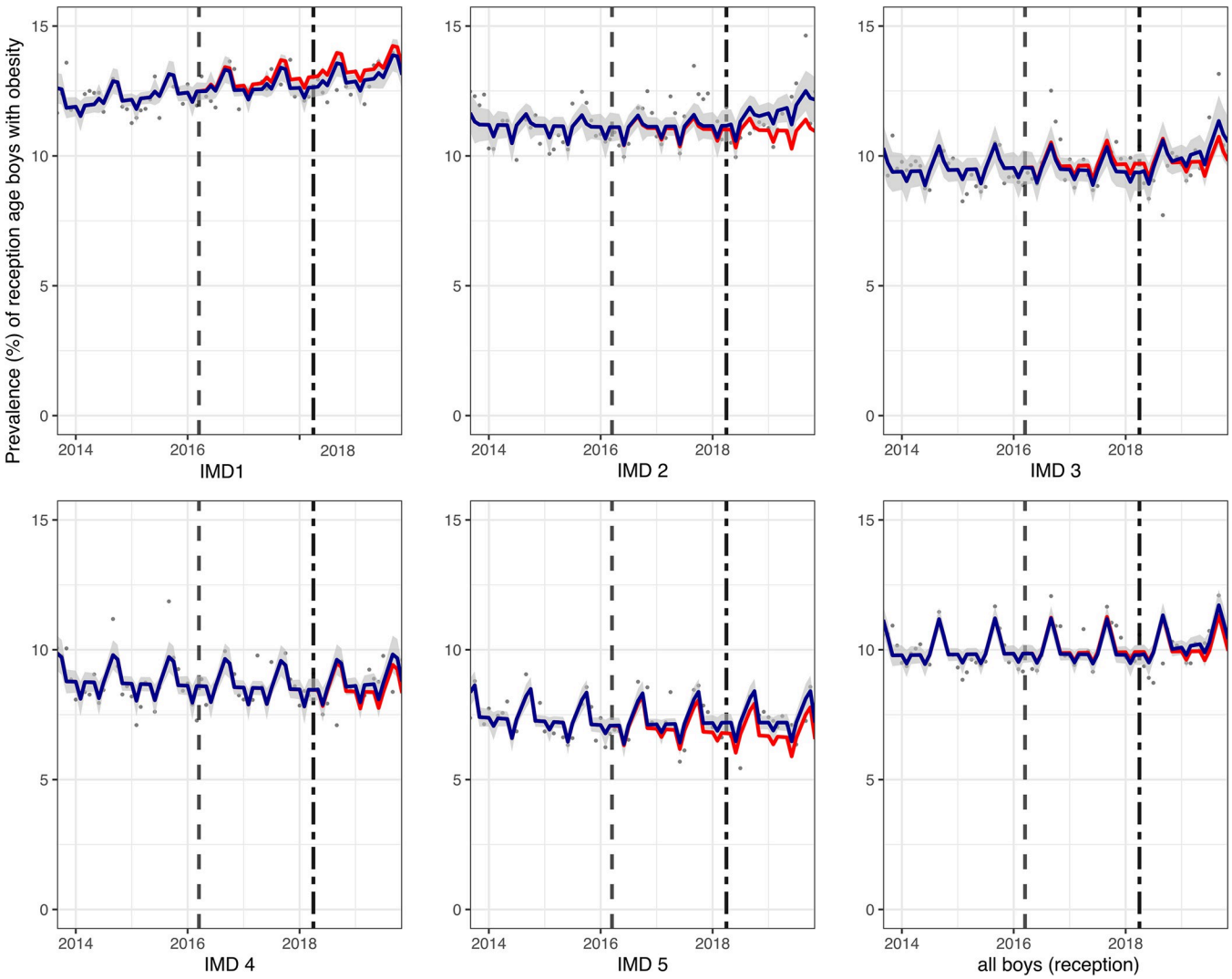

Fig 4. Prevalence (%) of obesity in boys in reception class (aged 4/5) between September 2013 and November 2019. Observed and modelled prevalence of obesity is shown by IMD quintile and overall. Dark blue points show observed data and dark blue lines (with grey shadows) shows modelled data (and 95% CIs) of obesity prevalence. The red line indicates the counterfactual line based on the pre-SDIL announcement trends (assuming the announcement and implementation had not occurred). The first and second dashed vertical lines indicate the announcement and implementation of the SDIL, respectively. CI, confidence interval; IMD, index of multiple deprivation; SDIL, soft drinks industry levy.

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increase (compared to a 1.6-PP absolute decrease observed in this study in 10- to 11-year-old girls 19 months after the levy was introduced) [38]. Moreover, similar to the findings of this study, no significant reductions in weight-related outcomes were observed in adolescent boys in Mexico. We note, however, that the tax implemented in Mexico is not directly comparable with the UK SDIL; in Mexico; the tax had a different design aimed at increasing the price to consumers resulting in 100% of the SSB tax being passed through to consumers, equating to a 14% increase in prices [49], and, importantly, the tax was included as a wider package of anti-obesity measures, which included charging 8% on high-energy foods [23]. We note the importance of the finding that the tax in Mexico was more effective in girls who were heavier. Similar analysis was not possible here because we only had access to repeated cross-sectional data, which cannot be linked over time.

Third, we found that reductions in obesity in relation to the levy were greatest in children who were older and from the most deprived areas. Previous studies have reported the same children are more likely to be higher consumers of SSBs [5,9,11–13]. This suggests a possible dose–response gradient between consumption levels and effectiveness of the levy in reducing obesity. This also adds to the growing international evidence that SSB taxes may reduce inequalities in diet-related health outcomes. For example, some studies from other countries have shown that lower-income households were more likely to reduce their purchases or intake of sugar from SSBs following introduction of SSB taxes [36,50,51], although this is not always the case [22,52,53].

In this study, we also demonstrate that the UK SDIL is not associated with a change in obesity prevalence in children in the first year of primary school. This result is congruous with findings from a cohort of British children showing that SSB consumption at ages 5 or 7 are not related to adiposity at age 9 years [54]. Added sugars from drinks make up 30% of all added sugars in the diet of young children (aged 1 to 3 years), but this increases to more than 50% by late adolescence [5]. The lower intake of sugars from soft drinks at very young ages may lower the potential of a tax on SSBs, making it harder to observe health effects at the population level. Fruit juices, which are not included in the levy, are thought to contribute similar amounts of sugar in young children's diets as SSBs and may explain why the levy alone is not sufficient to reduce weight-related outcomes in reception age children. In addition to drinks, confectionery, biscuits, desserts, and cakes are also important high-added sugar items, which are regularly consumed by young children and could be a target of additional obesity reduction strategies [5].

While our finding that the SDIL had greater impacts on obesity prevalence in girls than boys is consistent with previous studies [38], it is unclear why this might be the case, especially since boys were higher baseline consumers of SSBs [13]. One explanation is that there were factors (e.g., in food advertising and marketing) at work around the time of the announcement and implementation of the levy that worked against any associations of the SDIL among boys. There is evidence that soft drink manufacturers altered their marketing strategies in different ways in response to the SDIL including repackaging and rebranding products [55]. Numerous studies have found that boys are often exposed to more food advertising content than girls [56–59], both through higher levels of TV viewing [59] and through the way in which adverts are framed. Physical activity is often used to promote junk food, and boys, compared to girls, have been shown to be more likely to believe that energy-dense junk foods depicted in adverts will boost physical performance [56] and thus they are more likely to choose energy-dense, nutrient-poor products following celebrity endorsements. There is also evidence that girls tend to make healthier choices when it comes to diet (e.g., consuming more fruit and vegetables and less energy-dense foods) and other health behaviours (e.g., brushing teeth) [60]. One possibility for the observed differences between boys and girls may be that girls were more responsive to public health signalling arising from discussions around the SDIL or that they were more likely to choose drinks that had been reformulated to contain less sugar following the SDIL announcement.

Even the strongest association of the SDIL among the most levy-responsive groups (e.g., year 6 girls) reflected only a dampening of the rate of increase in obesity prevalence compared to the counterfactual rather than a reversal in trends. This highlights that alongside the SDIL, additional evidence-informed obesity reduction strategies need to be in place to improve weight-related outcomes, especially in boys and younger children, as they enter primary school education.

Strengths and limitations of the study

This study makes use of a unique and well-powered ongoing nationally representative sample covering over 90% of children aged 4 to 5 and 10 to 11 years in state-run primary schools over

the study period and tracks the prevalence of overweight and obesity in over 1 million school children annually. Obesity prevalence data were based on objective measures of height and weight rather than parental self-report, where there is a tendency to underestimate overweight [61]. The NCMP uses 85th and 95th centiles of the UK1990 growth reference to monitor overweight and obesity in children (accounting for age and sex), respectively [42,62]. However, other cut points are sometimes used [63], and there is some debate over whether this is the best measure of adiposity, particularly in younger children [64].

Parental consent in NCMP involves a selective opt-out, which is designed to increase participation rates. However, it has been suggested that girls with obesity are less likely to participate [65]. This may have led to underestimation of the association between SDIL on obesity prevalence in girls. These effects are, however, likely to be small given that obesity levels in girls have not changed dramatically and participation in the sample overall remained high throughout our study period. Socioeconomic disadvantage was assessed using an area-level indicator (IMD) of the school that each child attended, a less sensitive measure than capturing socioeconomic disadvantage at the household level. However, there is a strong correlation between school-level IMD and the proportion of pupils eligible for free school meals, a measure of the number of children attending a school with a low household income, [66] suggesting that the measure used here is a suitable proxy measure of household deprivation.

Data on time trends of expected childhood weight loss in relation to diet interventions are sparse with studies not monitoring weight-related outcomes with regularity and from early in the intervention. This makes it particularly challenging to estimate how long from the SDIL announcement we would expect to observe changes in obesity prevalence in children. However, there is evidence that changes in energy balance in children can lead to rapid changes in weight loss, for example, seasonal differences in BMI are observed in school children, with weight gain typically occurring during the summer periods especially in children with overweight or obesity [45]. Consistent with these observations, our statistical models and ITS graphs reveal spikes in obesity prevalence in the months following the summer holidays (September in reception and year 6 children, and October in children in reception) and dips in other months (e.g., in June and July) in some subgroups. These require further investigation that could contribute to understanding of seasonal variations in childhood obesity. Furthermore, our ITS graphs reveal that in some groups, there may be continued improvement in the longer term with a widening between counterfactual and observed values in, for example, year 6 girls (IMD 1, 2, and 5).

The ITS approach used modelled counterfactuals on the obesity prevalence trends immediately prior to the SDIL announcement. Given that estimates of the overall difference between observed and counterfactual obesity prevalence can be sensitive to the time points at which the counterfactuals are modelled, as part of a sensitivity analysis, we included two extra interruption points. The first additional interruption was 8 months post-announcement of SDIL, a time when reformulation of SSBs was visibly starting to increase; here we observed very similar findings to the main analysis indicating that they are robust. The second additional interruption was assigned to the date of the SDIL implementation; using this model, we observed fewer significant changes in obesity prevalence compared to the counterfactual (for example, no significant difference was observed in year 6 girls overall). This finding may be explained by the fact that companies had already reformulated most of their products prior to the implementation date and trajectories of obesity prevalence had responded rapidly. Furthermore, examining trajectories of "excess weight" prevalence rather than prevalence of obesity as the outcome of interest led to findings broadly consistent with the main analysis.

Conclusions

The UK SDIL was proposed by the UK government to tackle childhood obesity. The pattern of findings of this study suggests that the SDIL can contribute to reducing obesity prevalence in older primary school children. The SDIL announcement and implementation was associated with an overall relative decrease in obesity prevalence in year 6 girls aged 10 to 11 years of approximately 8% compared to the counterfactual scenario based on pre-announcement trends. These associations were even greater in girls from schools in the 40% most deprived areas, suggesting the SDIL could help to reduce inequalities in child obesity. Further obesity reduction policies are needed alongside taxes on SSBs to improve and reverse the current obesity prevalence in children.

Supporting information

S1 Checklist. RECORD checklist. RECORD, Reporting of studies Conducted using Observational Routinely-collected Data.
(DOCX)

S1 Fig. Schematic diagram of the interrupted time series. Blue solid lines indicate observed data. Dashed red lines represent counterfactuals. Counterfactual for (1) main analysis based on obesity prevalence trends from 09/2013–03/2016; (2)sensitivity analysis (a) based on obesity prevalence trends from 09/2013–12/2016; and (3)sensitivity analysis (b) based on obesity trends from 09/2013–04/2018.
(DOCX)

S1 Text. Model specifications for children in year 6 and reception class.
(DOCX)

S1 Table. Changes in obesity prevalence compared to a counterfactual scenario based on trends prior to 8 months post-announcement. Absolute and relative changes in prevalence of obesity (95% CIs), compared to a counterfactual scenario[1] based on trends prior to 8 months post-announcement, overall and by IMD in reception and year 6 children, 19 months post-implementation of UK SDIL. CI, confidence interval; IMD, index of multiple deprivation; SDIL, soft drinks industry levy.
(DOCX)

S2 Table. Changes in obesity prevalence compared to a counterfactual scenario based on trends prior to the SDIL implementation. Absolute and relative changes in prevalence of obesity (95% CIs), compared to a counterfactual scenario[1] based on pre-SDIL implementation trends, overall and by IMD in reception and year 6 children, 19 months post-implementation of UK SDIL. CI, confidence interval; IMD, index of multiple deprivation; SDIL, soft drinks industry levy.
(DOCX)

S3 Table. Changes in excess weight prevalence compared to a counterfactual scenario based on trends prior to the SDIL announcement. Absolute and relative changes in prevalence of excess weight (overweight or obesity) and 95% CIs, compared to a counterfactual scenario[1], based on pre-SDIL announcement trends, overall and by IMD in reception and year 6 children, 19 months post-implementation of UK SDIL. CI, confidence interval; IMD, index of multiple deprivation; SDIL, soft drinks industry levy.
(DOCX)

Author Contributions

Conceptualization: Steven Cummins, Oliver Mytton, Harry Rutter, Stephen J. Sharp, Martin White, Jean Adams.

Data curation: Nina T. Rogers.

Formal analysis: Nina T. Rogers.

Funding acquisition: Steven Cummins, Oliver Mytton, Harry Rutter, Martin White, Jean Adams.

Investigation: Nina T. Rogers, Jean Adams.

Methodology: Nina T. Rogers, Stephen J. Sharp.

Project administration: Catrin P. Jones, Jean Adams.

Supervision: Jean Adams.

Validation: Nina T. Rogers, Jean Adams.

Writing – original draft: Nina T. Rogers, Steven Cummins, Oliver Mytton, Harry Rutter, Stephen J. Sharp, Dolly Theis, Martin White, Jean Adams.

Writing – review & editing: Nina T. Rogers, Steven Cummins, Hannah Forde, Catrin P. Jones, Oliver Mytton, Harry Rutter, Stephen J. Sharp, Dolly Theis, Martin White, Jean Adams.

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