Title: Television advertisements for high sugar foods and beverages: Effect on children's snack food intake.

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Short title: High sugar TV adverts and children's food intake.

Abbreviations:

IMD: Index of Multiple Deprivation

SES: Socio-economic Status

DMFT: Decayed, Missing, Filled Teeth

BMI: Body Mass Index

Key words: food advertisements, sugar, obesity, dental caries

Abstract:

Energy-dense food advertising affects children's eating behaviour. However, the impact of high sugar food advertising specifically on the intake of sweet foods is underexplored. This study sought to determine whether children would increase their intake of sugar, and total energy, following high sugar food advertising (relative to toy advertising) and whether dental health, weight status, and socioeconomic status (SES) would moderate any effect. In a cross-over, randomised controlled trial, 101 UK children (40 male) aged 8-10 years were exposed to high sugar food/beverage and toy advertisements embedded within a cartoon. Their subsequent intake of snack foods and beverages varying in sugar content was measured. A dental examination was performed and height and weight measurements were taken. Home postcode provided by parents was used to assign participants to SES quintiles. Children consumed a significantly greater amount of energy (48.6kcal, 95% CI 13.5-83.7, p=0.007) and sugar (6.0g, 95% CI 1.3 to 10.7, p=0.012) following food advertisements compared with after toy advertisements. This was driven by increased intake of the items with most sugar (chocolate, jelly sweets). Children of healthy weight and with dental caries had the greatest intake response to food advertising exposure, but there were no differences by SES. Acute experimental food advertising exposure increases food intake in children. Specifically, high sugar food and beverage advertising promotes the consumption of high sugar food items. The debate around the negative health effects of food advertising on children should be widened to include dental health as well as overall dietary health and obesity.

Introduction:

The modern day food environment in high- and middle-income countries is characterised by the widespread availability and persistent marketing of ultra-processed food and non-alcoholic beverages that are high in fat, sugar and/or salt (HFSS). Concerns have been raised about the implications of such marketing (commercial promotion that includes advertising but also product placement, sponsorship, product design/packaging and point-of-sale promotions[1]) for children's health[2, 3, 4]. Exposure to HFSS advertising has a direct effect on children's food behaviours and diet-related health[5, 6, 7, 8, 9]. Youths of lower socioeconomic status (SES) may have greater exposure to HFSS advertising[10, 11, 12] and be more vulnerable to the effects[13, 14] relative to those of higher SES. Similarly, greater impact of advertising on food intake has been seen in children with overweight and obesity[15].

Debate has tended to focus on the promotion of energy-dense foods and whether this contributes to the development of childhood overweight[2, 8], but studies have also noted that children's food advertising exposure is largely for items potentially harmful to their dental health[16]. Whilst the global epidemic of obesity, including in children, and its economic cost is well documented[4, 17, 18], prevalence of dental caries has arguably received less attention[19] despite being recognised as a global public health concern by the World Health Organization (WHO)[20]. Untreated dental decay in primary teeth affects 560 million children worldwide[21]. Dental disease is associated with increased rates of school absenteeism[22] and work absenteeism by parents or guardians[23], with the direct costs of treatment alone estimated at US$298 million annually (4.6% of total global health expenditure)[19].

Evidence suggests that obesity and dental caries are related[24] and although both are multifactorial in their aetiology, a common risk factor is the excessive consumption of sugar[2, 25]. In 2015, the WHO published updated guidelines on sugar intake, recommending

that both adults and children should reduce their intake of free sugars to less than 10% of total energy intake, and ideally less than 5% (approximately 25 grams (6 teaspoons/day))[26].

However, the role of food marketing in driving chronic overconsumption of sugar in children and the associated dental consequences is unclear. There are some cross-sectional studies that suggest an association. For example, children who watch more television have been found to consume more soft drinks and have poorer oral hygiene[27] or to be more likely to consume cariogenic foods and have dental caries[28, 29] than those who watch less.

Numerous experimental studies show that television advertising for unhealthy foods in general increases immediate snack food (both sweet and savoury) intake in children[6]. However, there is a dearth of experimental evidence in relation to the impact of high sugar (cariogenic) food and beverage (hereafter, food) advertisements specifically or how intake of sweet items is affected. Gatou et al., (2016) showed that following food advertisement exposure (versus non-food), children chose significantly fewer healthy foods from a photograph-based checklist, and those with poor dental health in particular chose a higher percentage of unhealthy foods[30]. However, to our knowledge, no studies have used solely and specifically cariogenic food advertisements (rather than general HFSS products) as the experimental stimuli and included actual kilocalorie/sugar intake as an outcome measure. In addition, there is insufficient understanding of the potential moderating role of individual differences such as dental health, weight status and SES in this effect. The current study was designed to address these gaps.

The primary hypotheses were that all children would consume a greater amount of food overall (kilocalories, kcal) and sugar specifically (grams, g) following food advertisement exposure relative to non-food advertisement exposure. The secondary hypothesis was that

this increase in intake would be greatest for those children with dental caries experience, overweight or obesity, and/or lower SES.

Patients and Methods:

The research was conducted according to the Declaration of Helsinki. Ethical approval was obtained from the University of Liverpool Research Ethics Sub-committee for Non-invasive Procedures in January 2016 (RETH000945). Written informed consent was obtained from the school head teacher and parents. Verbal child assent to participate was also obtained. Parents were asked to indicate any history of anaphylaxis, food allergy or intolerance to the foods to be used in the study, these children would have been excluded from participating but no such cases were reported.

Participants

101 children (40 male) aged 8-10 years (mean 9.86 ± 0.54y) were recruited from a primary school in Merseyside, United Kingdom. The power calculation for the current study was based on 80% power and a two-sided significance level (alpha) of 0.05 to find a medium effect size for the food intake effect (our primary hypothesis) (d = 0.3, reflecting previous short-term advertising exposure studies[6]). This indicated a required sample of 90 participants; however, this was an opportunity sample with ~10% over recruitment included to allow for potential attrition (e.g. school absence). Data were collected during May and June 2016.

Design

The study design was adapted from similar studies previously conducted by the researchers[31, 32]. Participants were exposed to four food advertisements or four non-food advertisements

(all approximately 30 seconds long for a total advertisement exposure of two minutes, embedded within the same 21-minute episode of the TV cartoon "Scooby Doo") on two different occasions (each at a similar time of day) on a large projector screen in a spare school classroom. Counterbalancing of condition order was conducted using www.randomizer.org. A two-week interval between conditions was enforced to minimize the crossover effect from each exposure, and children were asked (via instructions to parents in the information sheet and reminder information sent prior to the study sessions) to keep other activity (e.g. breakfast consumption, physical activity) consistent on test days and the 24 hours prior. The food advertisements all promoted high sugar food and beverage items (snacks, confectionery, sugar-sweetened beverages) and the non-food advertisements were for toys. All advertisements were obtained from contemporary UK television recordings held by the researchers.

Procedure

Children were asked to indicate their level of hunger on a 'smiley face' 5-point Likert scale (adapted from a similar scale[33]). Participants then viewed the stimuli (cartoon with food/non-food advertisements embedded in the middle) in small groups (4-8 children). Groups were held consistent across the two testing sessions and each child always participated on the same day of the week and at the same time of day.

Following advertisements exposure on each occasion, children were each given an individual, standardized tray of pre-weighed snack foods and beverages. The items offered were chosen to represent options with a range of sugar content to allow variations in expression of food choice (towards or away from sweeter items) to be assessed, see Table 1. Orange juice was selected as the high sugar drink (rather than a sugar-sweetened carbonated

beverage or cordial based drink) for reasons of i) minimising provision of nutrient poor items to children and ii) experimental control (avoiding inconsistency in drink fizziness and individual preferences around strength of cordial dilutions). As evidence suggests that food advertising operates at a category (e.g. sugary drinks) level, rather than an individual product level [5], using a familiar and liked item was perceived as an appropriate option despite fruit juice typically being advertised to children less frequently than carbonated beverages.

[TABLE 1 HERE]

The food items were removed from all packaging and placed in plain white bowls. The beverages were provided in clear bottles with no labelling and a sports cap to prevent spillages. The children were allowed 15 minutes to eat and drink as much or as little as they wanted. They could, on request, receive more of any item. After 15 minutes the trays were collected. The remaining items were weighed, and subsequent calculations determined the amount of each item consumed and the overall kcal and sugar intake.

At the end of the second session, a dental examination was undertaken by two UK General Dental Council registered dentists (JK, RF). As children of this age are at different stages of dental development, only first permanent molars were examined. The dental examination involved a visual inspection under using a high-powered head-torch (Energizer Vision HD+ Focus headlight- 300 Lumens). A disposable mirror and probe (Kerr TotalCare, sterile dental mirror and periodontal probe) were used to explore the tooth surfaces. Any decayed, missing or filled teeth were noted and a Decayed, Missing, Filled Teeth (DMFT) score was recorded. DMFT is a long established and commonly used method of assessing dental caries prevalence[34]. Where possible children were assessed by both dentists independently (66 children were assessed by both dentists and the remainder by one dentist

(JK)). Inter-examiner reliability was calculated for DMFT. Also at the second session only, children's height (metres) and weight (kilograms) were measured using a stadiometer (Leicester Portable Height Measure: SECA) and digital scale accurate to 0.2kg (SECA 875 Flat Scales). These data were not obtained for two children.

Statistical Analysis

DMFT scores, representing experience of dental caries, were converted to a dichotomous 'present' (DMFT score of 1, 2, 3, or 4 indicating experience) or 'absent' (DMFT score of 0, no experience). BMI was calculated using height and weight data, and weight status was defined using cut-off points equivalent to adult BMIs of 25kg/m^2 (overweight) and 30kg/m^2 (obese)[35] respectively. Due to disparities in weight status group sizes, children with overweight and obesity were combined into a single 'overweight/obesity' group for analysis purposes. Parents provided the child's home postcode, which was used to calculate the Index of Multiple Deprivation (IMD) using the English indices of deprivation 2010 as markers of SES[36]. Using this tool, participants were assigned to one of five quintile groups ranging from "least deprived" to "most deprived".

Data were analysed using IBM ® SPSS ® Statistics Version 24 and SAS software version 9.4. Cohen's Kappa statistic was used to calculate the inter-examiner reliability of the duplicated dental examinations, this was 0.87 for DMFT with an observed agreement of 96.97%. The effect of advert type on overall intake of kcals and sugar was analysed using repeated measures mixed models, adjusting for the fixed effect of sequence (first or second) and random effect of group allocation. Differences in the effect of advertisement exposure in groups based on caries experience, weight status and SES were explored by adding these

variables and interaction terms to the models. All models were fitted using PROC MIXED in SAS.

Results:

Table 2 lists demographic and anthropometric characteristics of the completing participants. The levels of overweight and obesity recorded in the sample were broadly consistent with national statistics[37]. This was a relatively deprived sample, with 89.1% of participants falling into the two most deprived quintiles, and the proportion of children with caries experience (19.8%) was lower than might be anticipated based on UK national data[38].

[TABLE 2 HERE]

A paired t-test showed that hunger did not differ significantly across the two sessions (p>0.05) so this variable was not included in further analyses.

Overall intake

On average, children consumed a greater number of kcals following food advertisement exposure compared with after toy advertisements (see Table 3). The difference between advertisement types in least squares means adjusted for group and sequence was 48.6kcal (95% CI 13.5-83.7, p=0.007). The difference in adjusted means for sugar consumption was 6.0g (95% CI 1.3 to 10.7, p=0.012). These increases largely reflect greater consumption of chocolate and jelly sweets (the items with the greatest sugar content) following the food advertisements relative to the toy advertisements (see Table 3). No significant differences in drink consumption (drink choice or volume consumed) were seen between conditions.

[TABLE 3 HERE]

Intake and experience of dental caries

There was a significant interaction between advertisement exposure and experience of dental caries on intake in kcal (p=0.044). Adjusted mean differences in intake between food and toy advertisements were 31.0 kcal (95%CI -7.5 to 69.6) in those without caries experience, and 120.3 (95%CI 42.4 to 198.2) in those with caries experience. Sugar consumption also showed a statistically significant interaction effect (p=0.030), with adjusted mean differences of 3.5g (95%CI -1.6 to 8.6) in those without caries experience, and 16.2g (95%CI 5.9 to 26.5) in those with caries experience.

Intake and weight status

The kcal intake of children with overweight and obesity was slightly lower in the food advertisement condition relative to the toy advertisement condition (difference in adjusted means of -24.2kcal (95% CI -98.7, 50.3)) and the interaction term from the repeated measures mixed model showed the difference in response between that group and those of a healthy weight (who showed an adjusted mean increase in intake of 66.6kcal after food advertisements) was statistically significant (p=0.037). Similarly, children with overweight and obesity consumed slightly less sugar after food advertisements than after toy advertisements (adjusted mean reduction of 2.8 (95%CI -12.8 to 7.1)), but there was no statistically significant difference (p=0.060) in response when compared with those children of a healthy weight (who showed an adjusted mean increase in sugar intake after food advertisements of 8.1 (95% CI 2.8 to 13.3)).

Intake and SES

Inclusion of SES in the models did not show any statistically significant interaction effects.

Discussion:

Following exposure to cariogenic food and beverage advertisements, children in this study consumed a greater amount of the test items (both in terms of kilocalories and sugar content) relative to after toy advertisements. This is consistent with previous research both in terms of the observed differences in overall intake[6, 15] and the 'beyond-brand' nature of the advertising effect[39], whereby food advertisement exposure does not just influence consumption of the specific product(s) advertised but extends to others in the same category (in this instance, snacks)[40]. The effects were driven by increased intake specifically of the items with the greatest sugar content (chocolate and jelly sweets with 54.4g and 55g of sugar per 100g of product respectively) which is consistent with the conclusion of Hastings et al., that food marketing operates at a food type or category level[40].

Although the effects were relatively small (increases of 48.6 kcal and 6g sugar respectively), they should be considered in the context of children's overall energy balance and the so-called 'energy gap'[41]. A sustained daily overconsumption (relative to energy requirements) of just 46 kcal/day can be sufficient to lead to the development of overweight in children[42]. Indeed, the global rises in obesity prevalence are the result of relatively small but repeated, cumulative increases in overall energy intake by individuals[43]. Small, individual level effects can be hugely impactful when seen across populations[44]. Furthermore, the current study only examined short-term intake responses to acute advertisement exposure. In reality, children are continually exposed to food marketing delivered via numerous platforms (e.g. television, Internet, outdoor, event sponsorship, point of sale retail environments[45]) in many settings, and repeated over time. This 'real world'

experience of food marketing exposure is likely to lead to an amplification of the effects observed in this study.

There were differences in food intake response to the advertising exposure across sub-groups related to dental health. Children with experience of dental caries had a greater intake response relative to those with no experience of dental caries. This finding is consistent with that of Gatou et al.,[30]. This should not necessarily be taken as evidence that children with dental caries are more likely to respond to food advertising per se, as dental caries may simply be a proxy for prior intake of sugary foods or prior advertising exposure. Longitudinal research is needed to properly tease out the interrelationships between these factors and their causality.

There were also observed differences in food intake response to food advertisement exposure across weight status groups for kcal intake (but not sugar). However, this was in the opposite direction to that hypothesised as the children with overweight and obesity consumed fewer calories after food advertisement exposure than after the toy advertisements whereas those of a healthy weight consumed more. The extant evidence supports a causal link between food marketing exposure and weight gain in children[8] and previous research has suggested that this at least partly reflects a greater acute food intake response to the advertising content in children with overweight and obesity[15]. Our findings do not support this. However the effects observed here may have been driven by social desirability, in light of perceived links between self-efficacy and having overweight and obesity in childhood, as well as social devaluation and stigmatization of children with excess weight[46]. It may also reflect habitual behaviours of the healthy weight children, who may be more likely to be physically active and be permitted to consume sugar-containing snack foods at home. Advertising is thought to be influential across a hierarchy of behavioural outcomes[47], it is

currently unclear whether robust weight status effects occur consistently across any of these outcomes. These gaps in understanding should be addressed by future research.

There were also no observed differences in intake patterns across the five quintiles of SES. There is a marked socioeconomic gradient to obesity whereby in industrialised nations those of lower SES have a much greater risk of obesity[48], however, the current study does not support the premise that greater reactivity to advertising contributes to this phenomenon. This is in contrast to previous studies[13, 14] but may reflect the lack of variation in SES in this sample (the vast majority of participants fell in the two most deprived quintiles). Advertising could still contribute to the SES gradient to obesity via greater exposure of food marketing in low SES groups[10].

The lack of group differences appears to be at least partly an issue of power. The study was powered for our primary hypothesis (overall intake across advertisement conditions), not for the secondary considerations of dental caries, weight status or SES. It is clear that obesity and dental caries have common risk factors other than overconsumption of sugar, including SES[49], and larger studies with more heterogeneous samples will be required to explore the interrelationships between these factors and marketing further.

Limitations of the study

This paper describes a small experimental study, with a relatively homogeneous sample. The 5-point Likert scale for hunger has not been validated. The advertising exposure was of brief duration on each occasion (approximately two minutes) and immediate food and beverage intake was measured from a small selection of items. This within-subjects experimental design accounts for any underlying food preferences but does not measure sustained effects beyond the testing period or the effects of cumulative exposure. The particular selection of

foods offered for consumption may also be considered a limitation, as children had a binary choice between sweets and fruit and did not have the option of selecting savoury items (e.g. potato crisps) as an indication of reduced sweet preference. Because of this we are unable to fully disentangle whether the observed effects reflect changing preference for sugar content across advertising conditions or a category level (confectionery) cued consumption effect in the food advertising condition. In addition, although children were asked to keep other eating behaviour (e.g. breakfast consumption) and physical activity consistent across study days (and the prior 24-hour period), the level of compliance with these instructions is unknown. Fluid intake prior to the test sessions was also not controlled for, which may have influenced snack intake. Awareness of the dental examination taking place at the end of the second study session may also have affected eating behaviour (choice of snacks, level of consumption) in some participants.

Conclusion

To the authors' knowledge, this is the first study to have empirically tested the impact of exposure to high sugar food and beverage advertising specifically on intake of sweet foods while also exploring the role of dental health, body weight and SES in this effect. Exposure to such advertising did increase sugar and energy intake in this sample of children, and therefore these data have implications for dental health as well as general dietary-related health and body weight. This study adds to the body of evidence suggesting that the marketing of HFSS foods could negatively impact on sugar and energy intakes in children, and therefore supports action to reduce children's exposure to the advertising of HFSS foods across all broadcast and non-broadcast media.

Contributors' Statement:

Mr Kearney conceptualized and designed the study, co-ordinated data collection, collected data, carried out the initial analyses, and reviewed and revised the manuscript.

Dr Fitzgerald conceptualized and designed the study, drafted the protocol, collected data, and reviewed and revised the manuscript.

Dr Burnside conceptualized and designed the study, supervised statistical analysis, and reviewed and revised the manuscript.

Prof Higham conceptualized and designed the study, collected data, and reviewed and revised the manuscript.

Dr Flannigan and Prof Halford conceptualized and designed the study and reviewed and revised the manuscript.

Dr Boyland conceptualized and designed the study, supervised data collection, collected data, contributed to data analysis and critically reviewed and revised the manuscript for important intellectual content.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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TABLE 1. Nutritional composition of the test food and drink items.

Food/beverage item	Kilocalories (kcal) per 100g	Grams (g) of sugar per 100g
Foods		
Chocolate buttons	540.0	54.4
Jelly sweets	345.0	55.0
Grapes	66.0	13.0
Carrot sticks	42.0	7.2
Beverages		
Orange juice	47.0	10.5
Water	0.0	0.0

TABLE 2. Characteristics of completing participants.

Characteristic		Number	Percentage
Sex			
	Male	40	39.6
	Female	61	60.4
Age[a]			
	8	8	7.9
	9	46	45.5
	10	47	46.5
Socioeconomic status (SES)			
	Quintile 1 (Least deprived)	2	2.0
	Quintile 2	3	3.0
	Quintile 3	6	5.9
	Quintile 4	53	52.5
	Quintile 5 (Most deprived)	37	36.6
Weight status[b]			
	Normal weight	77	76.2
	Overweight/obesity	22	21.8
Caries experience (DMFT)			
	Absent	81	80.2
	Present	20	19.8

[a] Does not equal 100% due to rounding

[b] No weight or height data obtained for 2 study participants

TABLE 3. Mean sugar (g) and caloric (kcal) intake of individual items across advertisement conditions

Food/ beverage item	Mean intake after toy advertisements (g)	SD	Mean intake after food advertisements (g)	SD	Mean sugar intake after toy advertisements (g)	SD	Mean sugar intake after food advertisements (g)	SD	Mean caloric intake after toy advertisements (kcal)	SD	Mean caloric intake after food advertisements (kcal)	SD
Foods												
Chocolate buttons	46.9	35.6	51.6	32.5	25.5	19.4	28.1	17.7	252.7	193.0	278.7	175.7
Jelly sweets	40.9	41.0	48.6	44.5	22.5	22.6	26.7**	24.5	141.1	141.5	167.6**	153.7
Grapes	76.8	56.8	75.5	66.2	11.8	8.7	11.6	10.2	50.7	37.5	49.8	43.7
Carrot sticks	26.2	38.1	25.2	35.4	1.9	2.7	1.8	2.5	11.0	16.0	10.6	14.9
Beverages												
Orange juice	132.8	156.4	127.0	129.0	13.9	16.4	13.3	13.5	62.4	73.5	59.7	60.6
Water	147.5	138.0	152.1	136.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**471.1**	**211.2**	**479.9**	**175.8**	**75.6**	**36.6**	**81.6***	**33.2**	**518.0**	**255.7**	**566.4***	**229.9**

** p < 0.01, * p < 0.05; results from paired t-tests between toy and food conditions using actual means (data in text of results section are estimated least squares means from the model adjusting for group and sequence).