



Child-targeted TV advertising and preschoolers' consumption of high-sugar breakfast cereals

Meghan R. Longacre^{a,*}, Keith M. Drake^{b,c}, Linda J. Titus^{a,c,d}, Jennifer Harris^e, Lauren P. Cleveland^a, Gail Langeloh^a, Kristy Hendricks^a, Madeline A. Dalton^{a,c,f}

^a Department of Pediatrics, Geisel School of Medicine at Dartmouth, Lebanon, NH, USA

^b Greylock McKinnon Associates, Cambridge, MA, USA

^c The Dartmouth Institute for Health Policy and Clinical Practice, Geisel School of Medicine at Dartmouth, Lebanon, NH, USA

^d Department of Epidemiology, Geisel School of Medicine at Dartmouth, Lebanon, NH, USA

^e Rudd Center for Food Policy and Obesity, University of Connecticut, Storrs, CT, USA

^f Department of Community and Family Medicine, Geisel School of Medicine at Dartmouth, Lebanon, NH, USA

ARTICLE INFO

Article history:

Received 9 June 2016

Received in revised form

9 September 2016

Accepted 10 October 2016

Available online 14 October 2016

Keywords:

High-sugar breakfast cereal

Food marketing

Children

Television

Cereal consumption

ABSTRACT

Breakfast cereals represent the most highly advertised packaged food on child-targeted television, and most ads are for cereals high in sugar. This study examined whether children's TV exposure to child-targeted, high-sugar breakfast cereal (SBC) ads was associated with their consumption of those SBC brands. Parents of 3- to 5-year-old children were recruited from pediatric and Women, Infants, and Children (WIC) clinics in Southern New Hampshire, USA, and completed a cross-sectional survey between April–December 2013. Parents reported their child's consumption of SBC brands; whether their child had watched any of 11 kids' channels in the past week; their child's TV viewing time; and socio-demographics. Children's exposure to child-targeted SBC TV ads was calculated by combining TV channel and viewing time with advertising data for SBC ads aired on kids' TV channels during the same timeframe. Five hundred forty-eight parents completed surveys; 52.7% had an annual household income of \$50,000 or less. Children's mean age was 4.4 years, 51.6% were female, and 72.5% were non-Hispanic white. In the past week, 56.9% (N = 312) of children ate SBCs advertised on kids' channels. Overall, 40.6% of children were exposed to child-targeted SBC TV ads in the past week. In fully adjusted analyses, the number of SBC brands children consumed was positively associated with their exposure to child-targeted SBC ads. Children consumed 14% (RR = 1.14, 95% CI: 1.02, 1.27) more SBC brands for every 10 SBC ads seen in the past 7 days. Exposure to child-targeted SBC TV advertising is positively associated with SBC brand consumption among preschool-aged children. These findings support recommendations to limit the marketing of high-sugar foods to young children.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Public health advocates are concerned about the marketing of high-sugar, ready-to-eat breakfast cereals (SBCs) to young children (Federal Trade Commission, 2008; 2012; Institute of Medicine, 2006; World Health Organization, 2010). In the U.S., the breakfast cereal industry is the second leading food advertiser to children under age 12, spending \$173 million annually directly marketing

ready-to-eat cereals to children (Federal Trade Commission, 2012). Many ready-to-eat cereal brands have a lengthy history of marketing their products to child consumers, particularly by using animated brand mascots (e.g., General Mills' Trix rabbit; Kellogg's Tony the Tiger), and more recently through the use of cross-promotional tie-ins with popular licensed media characters (e.g., Nickelodeon's *SpongeBob SquarePants*) appearing on cereal boxes (Kraak & Story, 2015b). Ample evidence suggests that the cereals most heavily advertised to children are the least nutritious, primarily because they contain the greatest amounts of added sugars (Batada, Seitz, Wootan, & Story, 2008; Kraak & Story, 2015a; LoDolce, Harris, & Schwartz, 2013; Schwartz, Vartanian, Wharton, & Brownell, 2008; Schwartz et al., 2010). The Rudd Center for

* Corresponding author. Hood Center for Children and Families, Geisel School of Medicine at Dartmouth, One Medical Center Drive, HB 7465, Lebanon, NH 03756, USA.

E-mail address: Meghan.Longacre@Dartmouth.Edu (M.R. Longacre).

Food Policy and Obesity demonstrated that child-targeted cereals contained 57% more sugar than adult-targeted cereals (LoDolce et al., 2013; Rudd Center for Food Policy and Obesity, 2012). In an analysis of cereal brands, the Environmental Working Group found that 78% of child-targeted cereals contained over two teaspoons of sugar per serving (Environmental Working Group, 2014).

Television is the primary type of media used by preschool-age children (Common Sense Media, 2013), and much of child-targeted cereal marketing occurs on television (Federal Trade Commission, 2012). Ready-to-eat cereals represent the most highly advertised packaged-food category to children on TV, with estimates indicating children view hundreds of televised cereals ads annually (LoDolce et al., 2013; Powell, Szczypka, & Chaloupka, 2007). Hingle and colleagues analyzed a sample of food advertisements aired during children's TV programming in 2013 and compared product nutrient data to the voluntary nutrition guidelines proposed by a coalition of four federal agencies (Hingle, Castonguay, Ambuel, Smith, & Kunkel, 2015; Interagency Working Group on Foods Marketed to Children, 2011). Ready-to-eat cereals accounted for over one-third of TV ads in this sample, yet none of the advertised cereals met the federal nutrition guidelines for added sugar (i.e., not more than 8 g of sugar per serving) (Hingle et al., 2015). Exposure to child-targeted ready-to-eat cereal TV advertising is associated with family purchases of the advertised products. Using Nielsen household panel food purchasing data, Castetbon and colleagues showed that households were 13 times more likely to purchase child-targeted cereals advertised on TV than cereal brands without advertising (Castetbon, Harris, & Schwartz, 2012). That study, however, did not examine actual consumption of purchased cereals.

Globally, marketing of high-sugar, high-fat foods to children has been identified as a risk factor for childhood obesity (Healthy Eating Research, 2015; Institute of Medicine, 2006; White House Task Force on Childhood Obesity, 2010; World Health Organization, 2012). Numerous international studies – primarily using experimental designs in controlled laboratory settings – indicate that children's food preferences, requests, and short-term consumption are influenced by exposure to child-targeted food marketing (Boyland & Halford, 2013; Boyland et al., 2016; Cairns, Angus, Hastings, & Caraher, 2013; Harris, Pomeranz, Lobstein, & Brownell, 2009). Additional research in non-controlled settings is needed to understand the potential impact of food marketing on children's usual eating behaviors in real-world environments with greater external validity (Institute of Medicine, 2006; White House Task Force on Childhood Obesity, 2010). Research meeting this criteria is mounting (Andreyeva, Kelly, & Harris, 2011); however, to date this evidence is primarily for foods (e.g., fast food, sugar-sweetened beverages) other than ready-to-eat breakfast cereals. We are unaware of any studies that have quantified the association between children's exposure to SBC TV ads and their actual cereal consumption. The purpose of this study was to assess whether children's TV exposure to child-targeted SBC ads was associated with their consumption of those SBC brands outside of a laboratory setting.

2. Materials and methods

2.1. Study design

Between April 2013 and March 2014, trained research assistants invited parents at pediatric outpatient and Women, Infants, and Children (WIC) clinics, located in Manchester and Nashua, NH, to complete a 15-min written survey about children's media use and food choices. Our recruitment sites were chosen because they provide access to a broad cross-section of families with young

children located in our catchment areas. WIC is a supplemental nutrition program in the U.S. To qualify, families cannot earn more than 185% of the poverty income level. Surveys were pre-tested with a demographically comparable sample for comprehension, face validity, and completion time. Eligibility for study participation included children's age (3–5 years) and parents' ability to complete a written consent form and survey in English or Spanish. If parents had multiple age-eligible children, we selected the child present for an appointment. If more than one child had an appointment, we randomly selected one. Parents received a \$10 gift card and children received a toy for participating. The study was approved by [BLINDED] Institutional Review Board.

Seventy-one percent of eligible parents completed a survey. The primary reason for not participating was insufficient time (44% of refusals). For this analysis, we assessed data from 548 parents surveyed between April and December 2013, which corresponded to our advertising data time period.

2.2. Measures

2.2.1. SBC consumption

We examined ten SBCs that were top-ranked in terms of child-targeted advertising (Rudd Center for Food Policy and Obesity, 2012) and were advertised on kids' TV channels during the last three quarters of 2013 (Kantar Media, 2013). The sugar content for these SBCs in 2013 ranged from 9 to 12 g of added sugar per ounce of cereal (i.e., approximately one serving size). We ascertained the number of advertised SBC brands children consumed by asking parents, "In the past 7 days, did your child eat any of the following cereals? (Apple Jacks, Honey Nut Cheerios, Cocoa Puffs, Cinnamon Toast Crunch, Froot Loops, Frosted Flakes, Lucky Charms, Pebbles—all flavors, Reese's Puffs, Trix)?" Responses were combined into a single count variable indicating the number of SBC brands each child had eaten in the past 7 days. For simplicity, we hereafter refer to this as SBC consumption.

2.2.2. SBC TV Ad exposure

Children's exposure to child-targeted SBC TV ads was based on parental report of children's viewing time and channels watched. For viewing time, we asked, "On average, how many days a week does your child do the following activities: watch TV (regular, cable, or satellite)? (0, 1–2, 3–4, 5–6, 7 days)." We then asked, "On days when your child does the following activities, about how much time does your child spend: watching TV (regular, cable or satellite)?" [response choices ranged from 0 to 6+ hours with 30-min segments]. For channels, we asked, "In the past 7 days, has your child watched any of the following TV channels? [Boomerang; Cartoon Network; The Disney Channel; Disney Junior; Disney XD; The Hub (now called Discovery Family); Nickelodeon; Nick Jr.; Nicktoons; PBS Kids; Sprout]" For each child, we calculated weekly TV viewing time by multiplying the number of days/week by the number of hours/day the child watched TV. We then estimated each child's weekly exposure to specific TV channels by dividing weekly viewing time by the number of kids' channels the child watched in the past 7 days.

All child-targeted SBC ads aired on kids' channels between April–December 2013 were obtained from Kantar Media™, a company that tracks TV commercials on an hourly basis. We assumed that all cereal ads aired on kids' channels were child-targeted. The SBCs asked about in the survey accounted for 97.5% of all SBC ads aired on kids' channels during this time period. For each day, we calculated channel-specific averages of the number of SBC ads aired per hour between 6am and 11pm or during child programming. For example, we did not include ads aired during Nick-at-Nite, which begins as early as 8pm and shares channel

space with Nickelodeon, because its programming is aimed at older audiences. We then multiplied each child's channel-specific weekly exposure time by the average number of SBC ads aired per hour on that channel during the 7 days prior to each survey. The resulting advertising exposure score approximates the mean number of child-targeted SBC ads each child was exposed to during the week prior to the survey.

2.2.3. Covariates

In the parent survey, we assessed demographics (i.e., child gender, race, and age) and SES (i.e., child participation in WIC, parent education, and household income). We assessed children's other screen time (i.e., hours of DVD's/VHS, streaming, apps, internet use, and electronic games) using the TV viewing question format. We also measured the frequency with which children ate any type of cereal by asking parents, "How often does your child eat cereal? (Never; Less than once a week; 1–2 times a week; 3–4 times a week; 5 or more times a week)."

2.3. Statistical analysis

We used Poisson regression with robust variance estimates to calculate rate ratios for the number of SBC brands consumed in the past 7 days for every 10 SBC ads to which children were exposed (Huber, 1967; Zou, 2004). The fully adjusted model includes demographics, SES, and other screen time. To maximize the sample size, we used multiple imputation by chained equations to impute values for all variables in the multivariate models with missing data (0.2–5.8% per variable) (Azur, Stuart, Frangakis, & Leaf, 2011). All analyses were conducted in STATA version 14 (StataCorp LP, College Station, Texas).

3. Results

3.1. Sample characteristics

Children's mean age was 4.4 (SD = 0.8) years and 51.6% were female. Seventy-three percent were non-Hispanic white; the majority (59.4%) of the others were Latino. Most (86.7%) participating parents were mothers. Approximately half (52.7%) the parents reported an annual household income of \$50,000 or less; 48.5% reported "high school or less" as their highest level of education.

3.2. SBC advertising

Overall, 27,080 SBC ads were identified for this analysis. There was some variability in the distribution of advertising by SBC brand (i.e., 2.6%–13.5% of all SBC ads), but no single brand accounted for more than 14% of the SBC ads. Only five of the 11 kids' channels aired SBC ads during the study period, and over two-thirds of SBC ads aired on Nickelodeon (37.8%) and Nicktoons (33.3%) (Fig. 1).

3.3. Children's TV viewing and SBC advertising exposure

On average, children spent 21.5 (SD = 19.9) hours per week using electronic media. Children's viewing of regular, cable or satellite TV accounted for nearly half of their overall screen time, averaging 9.3 (SD = 8.3) hours per week. Eighty-nine percent of children watched at least one kids' TV channel (regardless of SBC advertising) during the week before the survey. Overall, these children viewed a mean of 3.2 (SD = 2.2) kids' channels. On average, during the 7 days preceding each survey, kids' channels aired between 0 and 2.7 SBC ads per hour (Table 1).

Less than half of children watched kids' channels with SBC advertising; thus only 40.6% were exposed to child-targeted SBC

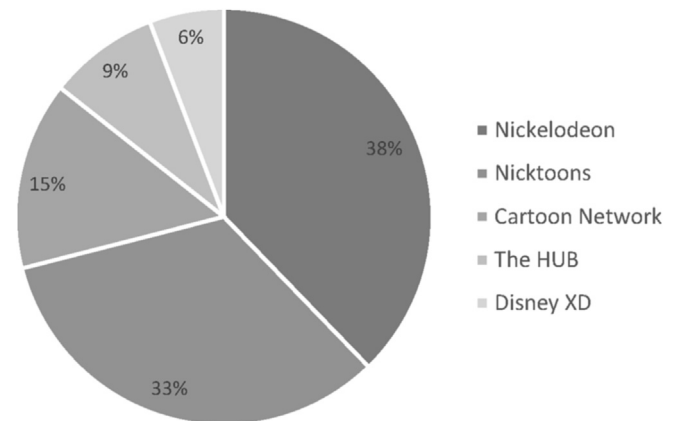


Fig. 1. Distribution of high-sugar breakfast cereal (SBC) ads by kids' channels.

ads during the past 7 days. Among these children, 39.0% had low exposure (≤ 3.0 ads), 33.0% moderate (3.01–10 ads), and 28.0% had high exposure (> 10 ads). Children's SBC ad exposure was positively associated with the following child characteristics: male gender ($p = 0.02$), non-white race ($p < 0.001$), and hours of TV viewing ($p < 0.001$); inversely associated with household income ($p = 0.021$) and parent education ($p < 0.001$); and not significantly associated with child age, WIC participation, or hours of other screen time.

3.4. Children's SBC consumption

Fifty-seven percent ($N = 312$) of children ate SBCs in the past week: 30.7% ate one SBC brand; 15.7% ate two SBC brands; and 10.6% ate 3 or more SBC brands. The most commonly consumed SBC brands were Honey Nut Cheerios and Froot Loops, consumed by 21.0% and 18.6% of children, respectively (Fig. 2). The number of SBC brands children consumed was positively associated with their SBC ad exposure (Table 2). In unadjusted analyses, older age (i.e., 5 years), WIC participation, and the frequency with which they ate any cereal also were associated with a greater number of SBC brands consumed, whereas non-Hispanic white race, higher household income, and having college-educated parents were associated with lower SBC consumption. Child gender, overall hours of TV watching, and hours of other screen time were not associated with the number of SBC brands children consumed in

Table 1

Percent of children who watched kids' channels and mean number of high-sugar breakfast cereal (SBC) ads aired per hour by channel during the 7 days preceding each survey.

Kids' channels	Viewed in past 7 days (N = 548) %	SBC Ads per hour ^a Mean (SD)
Disney Junior	58.0	0
PBS Kids	53.3	0
Nick Jr.	52.0	0
The Disney Channel	46.2	0
Sprout	33.9	0
Nickelodeon	28.5	2.7 (1.0)
Cartoon Network	17.7	1.0 (0.3)
The Hub ^b	11.0	0.5 (0.2)
Disney XD	8.2	0.3 (0.2)
Nicktoons	7.3	2.1 (0.7)
Boomerang	2.9	0

^a Only ads aired between 6am and 11pm or during child programming (for Nickelodeon and Cartoon Network) included.

^b Currently known as Discovery Family.

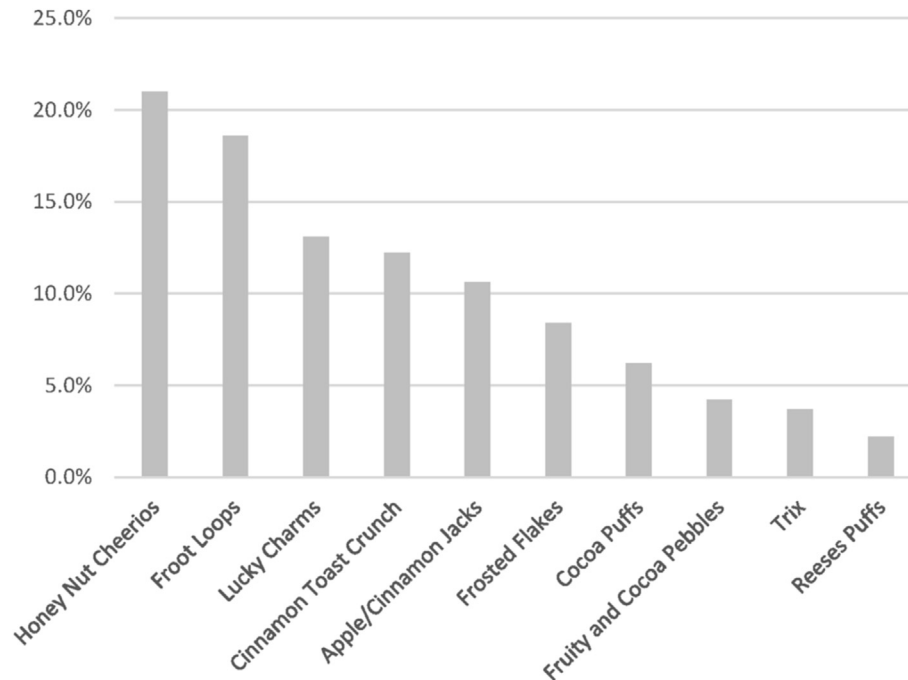


Fig. 2. Percent of children who ate high-sugar breakfast cereal (SBC) in the past 7 days, by brand.

the past 7 days (Table 2).

3.5. Association between Children's SBC consumption and exposure to advertising

In unadjusted analyses, children consumed 29% (RR = 1.29, 95% CI: 1.20, 1.39) more SBC brands for every 10 SBC ads viewed in the past 7 days (Table 3). After adjusting for child demographics, SES, and other screen time, children consumed 14% (RR = 1.14, 95% CI: 1.02, 1.27) more SBC brands for every 10 SBC ads seen in the past 7 days. In the fully adjusted model, child age and household income were also significant predictors of the number of SBC brands consumed. WIC participation, child race, and parent education were no longer significantly associated with SBC consumption in the adjusted model.

4. Discussion

This is the first study to demonstrate a significant positive relationship between exposure to child-targeted SBC TV advertising and young children's consumption of SBCs outside a laboratory setting. In our community-based sample of preschool-age children, the number of SBC brands consumed was positively associated with the average number of child-targeted SBC ads viewed in the past week. After adjusting for family SES, child demographics, WIC participation, and other screen time, we found the number of SBC brands consumed was 14% higher for every 10 SBC ads viewed in the past week.

Of the 10 SBCs we examined, nine contained 10 or more grams of sugar per ounce of cereal at the time of the study. In 2014, the Children's Food and Beverage Advertising Initiative (CFBAI), a U.S.-based industry self-regulatory organization with the stated intent to "shift the mix of foods advertised to children under 12 to encourage healthier dietary choices," (Better Business Bureau, 2014b) enacted updated nutrition criteria for products advertised to children. For ready-to-eat cereals, these revised nutrition standards specified that cereals advertised on child-targeted TV contain

no more than 10 g of total sugars per one ounce serving (Better Business Bureau, 2014a). Despite modest reductions in sugar content in response to the CFBAI updated nutrition guidelines (Better Business Bureau, 2014a), the sugar content of many advertised cereals remains very high and further efforts to reduce the marketing of SBCs to children are warranted. Internationally, countries (e.g., Norway, Sweden, France, United Kingdom) have already taken steps to reduce children's exposure to food advertising on TV (Bugge, 2016; Lloyd-Williams et al., 2014; World Health Organization, 2013). By demonstrating that exposure to SBC TV advertising was associated with intake of these high-sugar products among preschool-aged children, our results emphasize the public health importance of these efforts in the U.S.

Nearly six out of 10 children in this study consumed at least one of the measured SBC brands in the past week. In light of associations between children's sugar intake and a variety of indicators of compromised health status – including obesity, dental caries, and diabetes (Johnson et al., 2009; Welsh & Cunningham, 2011) – reducing dietary consumption of added sugars among U.S. children's diets is a national target (USDA, 2015). Efforts that promote children's consumption of low-sugar breakfast cereals is one strategy that would contribute to this goal (Guthrie & Morton, 2000). Few independently conducted studies have examined differences between low-sugar and high-sugar cereals on children's health (Castetbon et al., 2012). Ready-to-eat cereals represent one of the most popular choices for children's breakfast, and breakfast consumption has been linked to improved cognitive performance, better nutrient intake, and lower body mass index among children (Hoyland, Dye, & Lawton, 2009; Pollitt & Mathews, 1998; Rampsaud, Pereira, Girard, Adams, & Metzl, 2005). The food industry has suggested that children strongly prefer presweetened cereals, and that enhancing the palatability of cereal through added sugar is justified because it encourages consumption of a product fortified with other important nutrients (Albertson et al., 2009; Frary, Johnson, & Wang, 2004; Thompson, Franko, & Barton, 2008). However, experimental evidence suggests that children like and will consume low-sugar cereals, and those who eat low-

Table 2Number of high-sugar breakfast cereal (SBC) brands ^a children ate in the past 7 days by child-targeted SBC ad exposure ^b and sample characteristics.

	N	#SBC brands ^a consumed in past 7 days		Unadjusted Rate Ratio ^c	95% CI
		Mean	SD		
Child Characteristics					
SBC ad exposure ^b					
0 SBC ads	319	0.85	0.98	Ref	
0.01–3.0 SBC ads	85	1.14	1.36	1.34	(1.01,1.78)
3.01–10 SBC ads	72	1.23	1.52	1.46	(1.07,1.98)
>10 SBC ads	61	1.39	1.46	1.64	(1.23,2.19)
Gender					
Female	283	0.96	1.13	Ref	
Male	265	1.05	1.27	1.10	(0.90,1.34)
Age					
3 years	193	0.85	1.09	Ref	
4 years	208	0.99	1.24	1.16	(0.90,1.48)
5 years	146	1.22	1.24	1.43	(1.12,1.82)
Race					
Other	144	1.30	1.46	Ref	
Non-Hispanic White	380	0.90	1.08	0.69	(0.56,0.86)
WIC participation					
No	385	0.92	1.07	Ref	
Yes	163	1.20	1.43	1.30	(1.05,1.62)
TV watching(hours per week)					
<=1 h	55	1.00	1.05	Ref	
1.1–5 h	126	1.00	1.28	1.01	(0.71,1.44)
5.1–10 h	130	1.04	1.09	1.04	(0.75,1.44)
10.1–14 h	139	0.94	1.13	0.94	(0.66,1.32)
>14 h	83	1.14	1.46	1.14	(0.78,1.69)
Other screen time(hours per week)					
<=1 h	41	0.85	0.96	Ref	
1.1–5 h	164	0.85	1.14	0.99	(0.67,1.48)
5.1–10 h	133	1.04	1.09	1.22	(0.83,1.79)
10.4–14 h	56	1.02	1.17	1.19	(0.76,1.88)
>14 h	133	1.22	1.42	1.43	(0.96,2.12)
Frequency of cereal consumption(times per week)					
Never	21	0.14	0.36	Ref	
Less than once	48	0.69	0.99	4.81	(1.56,14.81)
1–2 times	135	0.85	1.03	6.02	(2.07,17.50)
3–4 times	200	1.12	1.19	7.84	(2.72,22.60)
5 or more times	135	1.26	1.42	8.82	(3.04,25.59)
Parent Characteristics					
Annual Household Income					
<=\$25,000	150	1.48	1.49	Ref	
\$25,001-\$50,000	122	0.95	0.98	0.64	(0.50,0.82)
\$51,001-\$100,000	156	0.91	1.12	0.62	(0.48,0.79)
>\$100,000	88	0.50	0.76	0.34	(0.24,0.48)
Parent Education					
High School or less	257	1.21	1.29	Ref	
Associates or technical degree	111	1.07	1.33	0.89	(0.68,1.16)
Bachelor's or graduate degree	162	0.67	0.86	0.55	(0.44,0.70)
Total	548	1.00	1.20		

^a Of the following brands advertised on kids' TV channels: Apple/Cinnamon Toast Crunch, Cocoa Puffs, Froot Loops, Frosted Flakes, Fruity & Cocoa Pebbles, Honey Nut Cheerios, Lucky Charms, Reese's Puffs, Trix.

^b Average number of SBC ads children saw on kids' TV channels in the past 7 days.

^c Significant rate ratios are highlighted in bold.

sugar cereals may also simultaneously increase their intake of other recommended food groups (e.g., fruits) (Harris, Schwartz, Ustjanauskas, Ohri-Vachaspati, & Brownell, 2011).

SBC companies have a long history of employing a continuous line-up of child-appealing brand mascots (e.g., Kellogg's *Tony the Tiger* on Frosted Flakes and *Toucan Sam* on Froot Loops) and cross promotional tie-ins with licensed media TV and movie characters (e.g., Nickelodeon's *SpongeBob SquarePants*; Marvel Comic's *Avengers* characters) to promote their products (Batada et al., 2008; Harris, Schwartz, & Brownell, 2010; Kraak & Story, 2015a, 2015b). SBC TV advertising features a wide array of brightly colored, animated and anthropomorphic characters that are highly appealing and memorable to young children. Evidence suggests that this marketing approach leads children to “pester” their

parents for the advertised product (Huang et al., 2016). Additionally, this approach prompts young children to request multiple cereals, including the one with the most recent appeal (Bridges & Briesch, 2006). Thus, it is not surprising that breakfast cereal advertising seems to encourage “brand switching” rather than brand loyalty, especially among young children (Shum, 2004). Based on this, we believe our outcome measure of the number of SBC brands consumed in the past week is a meaningful indicator of children's susceptibility to SBC advertising. However, we recognize that future work should also explore the extent to which exposure to child-directed SBC advertising impacts the quantity of SBC consumed.

Five of the 11 kids' channels that we examined aired SBC commercials. However, the hourly dose of SBC ads on these channels

Table 3

Rate ratios (RR) for high-sugar breakfast cereal (SBC) consumption^a in the past 7 days.

	Unadjusted		Adjusted ^c	
	RR	95% CI	RR ^d	95% CI
Child Characteristics				
SBC ad exposure (10 ads) ^b	1.29	(1.20,1.39)	1.14	(1.02,1.27)
Male			1.11	(0.96,1.29)
Age			1.20	(1.05,1.36)
Non-Hispanic white			0.84	(0.64,1.09)
WIC participation			0.98	(0.78,1.24)
Other screen time (hours per week)			1.06	(0.94,1.19)
Parent Characteristics				
Annual Household Income			0.79	(0.74,0.85)
Parent Education			0.92	0.75,1.14)

RR = rate ratio; 95% CI = 95% confidence interval.

^a Number of advertised SBC brands consumed in the past 7 days.

^b (Average number of SBC ads children saw on kids' TV channels in the past 7 days)/10.

^c Adjusted for all other variables in the table.

^d Significant rate ratios are highlighted in bold.

ranged widely, from 0.3 per hour (Disney XD) to nearly 3 ads per hour (Nickelodeon). Nickelodeon was the most viewed channel of the five channels with SBC advertising, with more than one-quarter of all preschoolers in our sample having watched it in the past week. Prior public health campaigns to reduce child-directed food advertising have focused specifically on Nickelodeon (Blumenthal, Rockefeller, Harkin, & Durbin, 2013; Center for Science in the Public Interest, 2013). These efforts seem warranted, given Nickelodeon's status as the primary point of exposure to SBC ads in this study. In contrast, almost sixty percent of children in this study were unexposed to child-targeted TV ads for SBCs because they only watched kids' channels without commercial food advertising (e.g., Disney Junior; PBS Kids) or did not watch any kids' channels at all. Notably, these children had the lowest weekly consumption of SBC brands. However, their SBC brand intake was not zero, indicating that SBC TV advertising is not the only factor associated with consumption. Other factors may include parental or sibling preference for the consumed SBC, as well as point-of-purchase exposure to advertising, both of which have been noted in prior research (Devi et al., 2014; Lapierre, Vaala, & Linebarger, 2011; Soo, Letona, Chacon, Barnoya, & Roberto, 2016). Identifying the relative influence of these other factors is an important direction for future work. Additionally, examining the impact of preschoolers' exposure to cereal marketing via online sources will be increasingly important as preschoolers' access to and time spent with mobile and online sources of media increases (Common Sense Media, 2013).

The current study is notable for several reasons. We focused on a preschool-age population, considered a highly vulnerable group given their developmental susceptibility to marketing that features familiar, beloved characters, and their cognitive inability to defend against such marketing practices (Harris & Graff, 2012; Harris, Brownell, & Bargh, 2009). Major cereal companies (e.g., General Mills, Kellogg, Post) indicate that they do not direct their TV advertising to children under age 6, but rather to children ages 6–11 (Better Business Bureau, 2014b). Our results demonstrate that younger children are nevertheless seeing these ads on TV, and are being affected by them. In our analyses, the overall average hours per week children watched TV, as well as their other screen time, were not associated with children's SBC brand consumption. This finding demonstrates that preschoolers' SBC consumption was not merely a function of high screen time, and supports the specificity of advertising exposure as a possible explanatory mechanism. We found similar associations between children's exposure to advertising and consumption of fast food in this sample (Dalton et al., in

press). Taken together, these studies quantify the link between advertising exposure and children's diet in real-world settings, and demonstrate that the effect is not limited to one particular food product. Our estimate of child TV viewing is consistent with other research using parental report of children's screen time (Common Sense Media, 2011, 2013; Loprinzi & Davis, 2015). Finally, our regional sample was diverse in terms of socioeconomic status.

We also note several study limitations. The study was conducted in a geographic area with limited racial and ethnic representation, and thus warrants replication in more diverse settings. We did not ask parents to report their child's weekly TV viewing time by channel, and thus the advertising exposure measure assumed equal exposure across the channels each child watched. If a child watched one channel much more frequently than another, this assumption could have resulted in exposure misclassification. However, the directionality of any potential bias is uncertain. Research with more precise measures of advertising exposure based on children's actual weekly viewing of channels is challenging with large samples but would offer more precise estimates. Similarly, our measure of children's SBC consumption is based on parent report rather than observation, which is possible in laboratory-based studies. Our measure of SBC consumption does not capture the overall quantity; however, children who consumed cereal more frequently also ate a wider variety of SBCs. We also did not inventory all cereals in the household, so cannot address whether advertised SBC were the only cereals in the household, or whether children were choosing these SBC over another cereal option. This would be an interesting direction for future work. Finally, the cross-sectional nature of the study design warrants caution in drawing conclusions about the causal nature of the association between advertising exposure and SBC brand consumption.

5. Conclusions

The current study demonstrates a significant positive association between preschoolers' exposure to child-targeted SBC TV ads and their intake of advertised SBC brands. These findings support the recommendations by the Institute of Medicine, the White House Task Force on Childhood Obesity, the World Health Organization, and other public health authorities, to restrict the marketing of foods high in sugar to young children (Healthy Eating Research, 2015; Institute of Medicine, 2006; White House Task Force on Childhood Obesity, 2010; World Health Organization, 2012).

Ethical standards disclosure

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Committee for the Protection of Human Subjects at Dartmouth College. Written informed consent was obtained from all subjects.

Financial support

This study was supported by the National Institutes of Health, grant number R01HD071021. The National Institutes of Health had no role in the design, analysis or writing of this article.

Authorship

MRL, LJT, KH, and MAD designed the study; LPC and GL were responsible for acquisition of the data; KMD and MAD analyzed the data; MRL, KMD and MAD drafted the manuscript; LJT and JH critically revised the manuscript; all authors had input on the interpretation of the data and approved the final version of the

manuscript.

Conflict of interest

All authors declare that we have *no conflicts of interest* in the authorship or publication of this manuscript.

Acknowledgements

This study was supported by the National Institutes of Health, grant number R01HD071021. The National Institutes of Health had no role in the design, analysis or writing of this article.

References

- Albertson, A. M., Affenito, S. G., Bauserman, R., Holschuh, N. M., Eldridge, A. L., & Barton, B. A. (2009). The relationship of ready-to-eat cereal consumption to nutrient intake, blood lipids, and body mass index of children as they age through adolescence. *Journal of the American Dietetic Association*, 109(9), 1557–1565. <http://doi.org/10.1016/j.jada.2009.06.363>.
- Andreyeva, T., Kelly, I. R., & Harris, J. L. (2011). Exposure to food advertising on television: Associations with children's fast food and soft drink consumption and obesity. *Economics & Human Biology*, 9(3), 221–233. <http://doi.org/10.1016/j.ehb.2011.02.004>.
- Azur, M. J., Stuart, E. A., Frangakis, C., & Leaf, P. J. (2011). Multiple imputation by chained equations: What is it and how does it work? *International Journal of Methods in Psychiatric Research*, 20(1), 40–49. <http://doi.org/10.1002/mpr.329>.
- Batada, A., Seitz, M. D., Wootan, M. G., & Story, M. (2008). Nine out of 10 food advertisements shown during Saturday morning children's television programming are for foods high in fat, sodium, or added sugars, or low in nutrients. *Journal of the American Dietetic Association*, 108(4), 673–678. <http://doi.org/10.1016/j.jada.2008.01.015>.
- Better Business Bureau. (2014a). *2014 cereals snapshot*. Retrieved June 6, 2016, from <https://www.bbb.org/globalassets/shared/media/cfbai/cereal-fact-sheet-march-2014.pdf>.
- Better Business Bureau. (2014b). *Children's food and beverage advertising initiative: Program and core principles, at a glance*. Retrieved June 1, 2016, from https://www.bbb.org/globalassets/local-bbbs/council-113/media/cfbai/program-and-core-principles_for-online-access.pdf.
- Blumenthal, R., Rockefeller, J. D. I., Harkin, T., & Durbin, R. J. (2013). *Press Release. Blumenthal issues letter calling on Nickelodeon to prohibit advertisements that market unhealthy food to children*. Retrieved June 1, 2016, from <https://www.blumenthal.senate.gov/>.
- Boylard, E. J., & Halford, J. C. G. (2013). Television advertising and branding. Effects on eating behaviour and food preferences in children. *Appetite*, 62, 236–241. <http://doi.org/10.1016/j.appet.2012.01.032>.
- Boylard, E. J., Nolan, S., Kelly, B., Tudur-Smith, C., Jones, A., Halford, J. C., et al. (2016). Advertising as a cue to consume: A systematic review and meta-analysis of the effects of acute exposure to unhealthy food and nonalcoholic beverage advertising on intake in children and adults. *The American Journal of Clinical Nutrition*, 103(2), 519–533. <http://doi.org/10.3945/ajcn.115.120022>.
- Bridges, E., & Briesch, R. A. (2006). The “nag factor” and children's product categories. *International Journal of Advertising: The Review of Marketing Communications*, 25(2), 157–187.
- Bugge, A. B. (2016). Food advertising towards children and young people in Norway. *Appetite*, 98, 12–18. <http://doi.org/10.1016/j.appet.2015.12.008>.
- Cairns, G., Angus, K., Hastings, G., & Caraher, M. (2013). Systematic reviews of the evidence on the nature, extent and effects of food marketing to children. A retrospective summary. *Appetite*, 62, 209–215. <http://doi.org/10.1016/j.appet.2012.04.017>.
- Castetbon, K., Harris, J. L., & Schwartz, M. B. (2012). Purchases of ready-to-eat cereals vary across US household sociodemographic categories according to nutritional value and advertising targets. *Public Health Nutrition*, 15(8), 1456–1465. <http://doi.org/10.1017/S1368980011003065>.
- Center for Science in the Public Interest. (2013). *Nickelodeon: Marketing obesity to kids*. Retrieved June 1, 2016, from https://cspinet.org/new/pdf/nickelodeon_brief_2013.pdf.
- Common Sense Media. (2011). *Zero to eight: Children's media use in America* (San Francisco, CA).
- Common Sense Media. (2013). *Zero to eight: Children's media use in America 2013* (San Francisco, CA).
- Dalton, M. A., Longacre, M. R., Drake, K. M., Cleveland, L. P., Harris, J. L., Hendricks, K., et al. (2016). Child-targeted fast food TV advertising exposure linked with fast food intake among preschoolers. *Public Health Nutrition*.
- Devi, A., Eyles, H., Rayner, M., Ni Mhurchu, C., Swinburn, B., Lonsdale-Cooper, E., et al. (2014). Nutritional quality, labelling and promotion of breakfast cereals on the New Zealand market. *Appetite*, 81, 253–260. <http://doi.org/10.1016/j.appet.2014.06.019>.
- Environmental Working Group. (2014). *Children's cereals: Sugar by the pound*. Retrieved June 5, 2016, from <http://www.ewg.org/research/childrens-cereals-sugar-pound/cereals-contain-far-more-sugar-experts-recommend>.
- Federal Trade Commission. (2008). *Marketing food to children and adolescents. A review of industry expenditures, activities, and self-regulation. A report to Congress*. Retrieved May 20, 2016, from <https://www.ftc.gov/reports/marketing-food-children-adolescents-review-industry-expenditures-activities-self-regulation>.
- Federal Trade Commission. (2012). *A review of food marketing to children and adolescents: Follow up report*. Retrieved May 20, 2016, from <https://www.ftc.gov/sites/default/files/documents/reports/review-food-marketing-children-and-adolescents-follow-report/121221foodmarketingreport.pdf>.
- Frary, C. D., Johnson, R. K., & Wang, M. Q. (2004). Children and adolescents' choices of foods and beverages high in added sugars are associated with intakes of key nutrients and food groups. *The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine*, 34(1), 56–63.
- Guthrie, J. F., & Morton, J. F. (2000). Food sources of added sweeteners in the diets of Americans. *Journal of the American Dietetic Association*, 100(1), 43–51. quiz 49–50. [http://doi.org/10.1016/S0002-8223\(00\)00018-3](http://doi.org/10.1016/S0002-8223(00)00018-3).
- Harris, J. L., Brownell, K. D., & Bargh, J. A. (2009). The food marketing defense Model: Integrating psychological research to protect youth and inform public policy. *Social Issues and Policy Review*, 3(1), 211–271. <http://doi.org/10.1111/j.1751-2409.2009.01015.x>.
- Harris, J. L., & Graff, S. K. (2012). Protecting young people from junk food advertising: Implications of psychological research for first amendment law. *American Journal of Public Health*, 102(2), 214–222. <http://doi.org/10.2105/AJPH.2011.300328>.
- Harris, J. L., Pomeroy, J. L., Lobstein, T., & Brownell, K. D. (2009). A crisis in the marketplace: How food marketing contributes to childhood obesity and what can be done. *Annual Review of Public Health*, 30, 211–225. <http://doi.org/10.1146/annurev.publhealth.031308.100304>.
- Harris, J. L., Schwartz, M. B., & Brownell, K. D. (2010). Marketing foods to children and adolescents: Licensed characters and other promotions on packaged foods in the supermarket. *Public Health Nutrition*, 13(3), 409–417. <http://doi.org/10.1017/S1368980009991339>.
- Harris, J. L., Schwartz, M. B., Ustjanskas, A., Ohri-Vachaspati, P., & Brownell, K. D. (2011). Effects of serving high-sugar cereals on children's breakfast-eating behavior. *Pediatrics*, 127(1), 71–76. <http://doi.org/10.1542/peds.2010-0864>.
- Healthy Eating Research. (2015). *Recommendations for responsible food marketing to children*. Retrieved May 25, 2016, from <http://thehealthyeatingresearch.org/research/recommendations-for-responsible-food-marketing-to-children/>.
- Hingle, M. D., Castonguay, J. S., Ambuel, D. A., Smith, R. M., & Kunkel, D. (2015). Alignment of Children's food advertising with proposed federal guidelines. *American Journal of Preventive Medicine*, 48(6), 707–713. <http://doi.org/10.1016/j.amepre.2015.01.004>.
- Hoyland, A., Dye, L., & Lawton, C. L. (2009). A systematic review of the effect of breakfast on the cognitive performance of children and adolescents. *Nutrition Research Reviews*, 22(2), 220–243. <http://doi.org/10.1017/S09545422409990175>.
- Huang, C. Y., Reisch, L. A., Gwozdz, W., Molnár, D., Konstabel, K., Michels, N., ... Lissner, L. (2016). Pester power and its consequences: Do European children's food purchasing requests relate to diet and weight outcomes? *Public Health Nutrition*, 19(13), 2393–2403. <http://doi.org/10.1017/S136898001600135X>.
- Huber, P. (1967). *The behavior of maximum likelihood estimates under nonstandard conditions*. Berkeley, CA: University of California Press.
- Institute of Medicine. (2006). *Food marketing to children and Youth: Threat or opportunity*. Washington, D.C.: The National Academies Press.
- Interagency Working Group on Foods Marketed to Children. (2011). *Preliminary proposed nutrition principles to guide industry self-regulatory efforts*. Retrieved June 1, 2016, from https://cspinet.org/new/pdf/FTC_foodmarket_factsheet_110428.pdf.
- Johnson, R. K., Appel, L. J., Brands, M., Howard, B. V., Lefevre, M., Lustig, R. H., ... American Heart Association Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism and the Council on Epidemiology and Prevention. (2009). Dietary sugars intake and cardiovascular health: A scientific statement from the American heart association. *Circulation*, 120(11), 1011–1020. <http://doi.org/10.1161/CIRCULATIONAHA.109.192627>.
- Kantar Media. (2013). *AdScope*.
- Kraak, V. I., & Story, M. (2015a). An accountability evaluation for the industry's responsible use of brand mascots and licensed media characters to market a healthy diet to American children. *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity*, 16(6), 433–453. <http://doi.org/10.1111/obr.12279>.
- Kraak, V. I., & Story, M. (2015b). Influence of food companies' brand mascots and entertainment companies' cartoon media characters on children's diet and health: A systematic review and research needs. *Obesity Reviews*, 16(2), 107–126. <http://doi.org/10.1111/obr.12237>.
- Lapierre, M. A., Vaala, S. E., & Linebarger, D. L. (2011). Influence of licensed spokescharacters and health cues on children's ratings of cereal taste. *Archives of Pediatrics & Adolescent Medicine*, 165(3), 229–234. <http://doi.org/10.1001/archpediatrics.2010.300>.
- Lloyd-Williams, F., Bromley, H., Orton, L., Hawkes, C., Taylor-Robinson, D., O'Flaherty, M., ... Leeder, S. (2014). Smorgasbord or symphony? Assessing public health nutrition policies across 30 European countries using a novel framework. *BMC Public Health*, 14(1), 1195. <http://doi.org/10.1186/1471-2458-14-1195>.
- LoDolce, M. E., Harris, J. L., & Schwartz, M. B. (2013). Sugar as part of a balanced breakfast? What cereal advertisements teach children about healthy eating.

- Journal of Health Communication*, 18(11), 1293–1309. <http://doi.org/10.1080/10810730.2013.778366>.
- Loprinzi, P. D., & Davis, R. E. (2015). Secular trends in parent-reported television viewing among children in the United States, 2001–2012. *Child: Care, Health and Development*. <http://doi.org/10.1111/cch.12304>.
- Pollitt, E., & Mathews, R. (1998). Breakfast and cognition: An integrative summary. *The American Journal of Clinical Nutrition*, 67(4), 804S–813S.
- Powell, L. M., Szczypka, G., & Chaloupka, F. J. (2007). Exposure to food advertising on television among US children. *Archives of Pediatrics & Adolescent Medicine*, 161(6), 553–560. <http://doi.org/10.1001/archpedi.161.6.553>.
- Rampersaud, G. C., Pereira, M. A., Girard, B. L., Adams, J., & Metz, J. D. (2005). Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. *Journal of the American Dietetic Association*, 105(5), 743–760. quiz 761–2. <http://doi.org/10.1016/j.jada.2005.02.007>.
- Rudd Center for Food Policy and Obesity. (2012). *Cereal FACTS 2012: A spoonful of progress in a bowl full of unhealthy marketing to children*. Retrieved May 20, 2016, from http://www.cerealfacts.org/media/Cereal_FACTS_Report_2012_7.12.pdf.
- Schwartz, M. B., Ross, C., Harris, J. L., Jernigan, D. H., Siegel, M., Ostroff, J., et al. (2010). Breakfast cereal industry pledges to self-regulate advertising to youth: Will they improve the marketing landscape? *Journal of Public Health Policy*, 31(1), 59–73. <http://doi.org/10.1057/jphp.2009.50>.
- Schwartz, M. B., Vartanian, L. R., Wharton, C. M., & Brownell, K. D. (2008). Examining the nutritional quality of breakfast cereals marketed to children. *Journal of the American Dietetic Association*, 108(4), 702–705. <http://doi.org/10.1016/j.jada.2008.01.003>.
- Shum, M. (2004). Does advertising overcome brand loyalty? Evidence from the breakfast-cereals market. *Journal of Economics & Management Strategy*, 13(2), 241–272.
- Soo, J., Letona, P., Chacon, V., Barnoya, J., & Roberto, C. A. (2016). Nutritional quality and child-oriented marketing of breakfast cereals in Guatemala. *International Journal of Obesity* (2005), 40(1), 39–44. <http://doi.org/10.1038/ijo.2015.161>.
- Thompson, D., Franko, D. L., & Barton, B. A. (2008). Concern over ready-to-eat breakfast cereals. *Journal of the American Dietetic Association*, 108(10), 1617–1618. author reply 1619–20. <http://doi.org/10.1016/j.jada.2008.08.034>.
- USDA. (2015). *Dietary guidelines for americans 2015–2020, eighth edition*. Retrieved June 6, 2016, from <http://health.gov/dietaryguidelines/2015/guidelines/executive-summary/>.
- Welsh, J. A., & Cunningham, S. A. (2011). The role of added sugars in pediatric obesity. *Pediatric Clinics of North America*, 58(6), 1455–1466. <http://doi.org/10.1016/j.pcl.2011.09.009>.
- White House Task Force on Childhood Obesity. (2010). *Solving the problem of childhood obesity within a generation*. Retrieved June 16, 2016, from <http://www.letsmove.gov/white-house-task-force-childhood-obesity-report-president>.
- World Health Organization. (2010). *Set of recommendations on the marketing of foods and non-alcoholic beverages to children*. [http://doi.org/ISBN 978 92 4 150021 0](http://doi.org/ISBN%20978%2092%204%20150021%200).
- World Health Organization. (2012). *A framework for implementing the set of recommendations on the marketing of foods and non-alcoholic beverages to children*. Retrieved June 5, 2016, from http://www.who.int/dietphysicalactivity/framework_marketing_food_to_children/en/.
- World Health Organization. (2013). *Marketing of foods high in fat, salt, and sugar to children: Update 2012–2013* (Copenhagen).
- Zou, G. (2004). A modified poisson regression approach to prospective studies with binary data. *American Journal of Epidemiology*, 159(7), 702–706.