Unhealthful Food-and-Beverage Advertising in Subway Stations: Targeted Marketing, Vulnerable Groups, Dietary Intake, and Poor Health

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Abstract Unhealthful food-and-beverage advertising often targets vulnerable groups. The extent of such advertising in subway stations has not been reported and it is not clear how ad placement may relate to subway ridership or community demographics, or what the implications might be for diets and diet-related health in surrounding communities. Riding all subway lines ($n = 7$) in the Bronx, NY, USA, investigators systematically assessed all print ads ($n = 1586$) in all stations ($n = 68$) in 2012. Data about subway ridership came from the Metropolitan Transportation Authority. Demographic data on surrounding residential areas came from the U.S. Census Bureau. Data on dietary intake and diet-related conditions came from a city health-department survey. There were no ads promoting “more-healthy” food-or-beverage items (i.e., fruits, vegetables, whole grains, nuts, water or milk). There were many ads for “less-healthy” items (e.g., candies, chips, sugary cereals, frozen pizzas, “energy” drinks,

coffee confections, hard alcohol, and beer). Ad placement did not relate to the number of riders entering at stations. Instead, exposure to food-or-beverage ads generally, and to “less-healthy” ads particularly (specifically ads in Spanish, directed at youth, and/or featuring minorities), was directly correlated with poverty, lower high-school graduation rates, higher percentages of Hispanics, and/or higher percentages of children in surrounding residential areas. Correlations were robust to sensitivity analyses. Additional analyses suggested correlations between ad exposures and sugary-drink consumption, fruit-and-vegetable intake, and diabetes, hypertension, and high-cholesterol rates. Subway-station ads for “less-healthy” items were located disproportionately in areas home to vulnerable populations facing diet and diet-related-health challenges. The fact that uneven ad placement did not relate to total rider counts suggests ads were not directed at the largest possible audiences but rather targeted to specific groups.

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Introduction

Food and beverage companies often target [1–3] and racial/ethnic minorities [4] with ads for unhealthful

products. Most research on targeted marketing has focused on screen ads (e.g., television, computer, and mobile-device advertising) [1]. There has been less research on print advertising, particularly ads in spaces where people go about their daily activities.

A few studies have assessed outdoor print ads in spaces such as residential areas. For example, studies have shown higher densities and percentages of ads for high-calorie, low nutrient-dense foods and beverages in lower-income and minority neighborhoods (particularly African American and, to a lesser extent, Latino communities) [5, 6]. One study showed that outdoor ads for sugary beverages, fast food, and alcohol were clustered around child-serving institutions like day-care centers, libraries, and schools, particularly in black communities [7].

Print advertising in communities also appears in spaces around mass transit, for example in subway stations. Subway-station ads may provide particularly substantial exposures given possible wait times for trains and multiple ads on platforms, especially relative to other outdoor advertisement that might be less numerous, less concentrated, and only glimpsed briefly in walking or driving by.

Studies of subway-stations ads have found more ads for alcohol in stations in high-poverty neighborhoods [8], with likely substantial exposure for public school children [9]. Beyond alcohol advertising though, it is not clear to what extent ads for other beverages or for foods are found in subway stations, how placement of ads may relate to subway ridership, or what the associations might be with diet and diet-related health in surrounding communities.

The current study sought to assess all print advertising in all stations of a subway system for large urban county. The goal was to determine how placement of ads for foods and beverages related to subway ridership and to the demographics, dietary intake, and prevalences of diet-related conditions in the residential areas surrounding stations.

Methods

Researchers rode all subway lines ($n = 7$) in the Bronx, NY, USA, and systematically assessed all print ads ($n = 1586$) in all stations ($n = 68$) during summer 2012. Ads could appear anywhere from entrances to exits along train platforms and could include wall posters, free-standing billboards, or other signage (e.g., on trash

receptacles, turnstiles, station clocks, or benches) promoting any product, service, or organization. Assessment was not limited to commercial-grade signage, although no less-formal ads (e.g., paper fliers) were observed. Researchers noted the total number of distinct ads within each station as well as the number of duplicates (i.e., multiple instances of the same ad).

Assessment of each ad included the brand or organization, the product or service, the language of any text (English vs. other), and the measured surface area (height $\times$ width). Through a consensus process, researchers decided whether ads were directed at minorities (i.e., featured models with unambiguously black or brown skin or unambiguously non-Caucasian faces) or directed at youth (i.e., featured children, children's toys or make-believe children's characters).

For ads promoting foods, consistent with the latest Dietary Guidelines for Americans [10], investigators distinguished between "more-healthy" items (i.e., fruits, vegetables, whole grains, nuts) and "less-healthy" items (i.e., prepared fast foods like hamburgers, hot dogs, fries, and fried chicken, and pre-packaged processed items like candies, cakes, cookies, ice cream, chips, processed meats, and microwave snacks). For ads promoting beverages, "more-healthy" items included water and milk and "less-healthy" items included alcohol and sugar-added drinks. Beverages such as diet drinks and juices were neither "more-healthy" nor "less-healthy" (and ultimately, there were no ads for these kind of beverages).

Ridership data (counts of the number of people entering the subway system through turnstiles at each station) came from the Metropolitan Transportation Authority (MTA) [11]. Data about the residential areas where riders entered the system came from the U.S. Census and a population survey from the city health department.

U.S. Census data provided demographic information like poverty rates, racial/ethnic composition, high-school graduation rates, and the percentage of children residing in the areas surrounding stations [12, 13]. Demographic values used in analyses were the aggregated population-weighted means of values for the census tract containing the station along with all census tracts having any border within a ¼-mile (by street network) around the station (ranging from 1 to 10 census tracts per station).

Survey data from the city health department provided information on dietary intake and diet-related conditions [14]. The measures of dietary intake were self-reports of

fruits and/or vegetables consumed yesterday and the average number of sugary drinks consumed per day. Diet-related conditions included diabetes (ever given this diagnosis by a physician), hypertension (currently taking medication for blood pressure), dyslipidemia (currently taking medication for cholesterol), and obesity (body mass index >30 based on self-reported height and weight). All of these data were available in aggregate at the level of united hospital fund areas (UHFs). The Bronx has five UHFs.

Due to imprecision in some area-level estimates [15], and so as to avoid assumptions about the distributions of the data, all statistical analyses were non-parametric. Mann–Whitney U tests assessed differences between residential-area demographics among stations featuring various kinds of ads. Spearman correlations described relationships between various ad exposures and the demographic, diet, and diet-related health characteristics of residential areas surrounding stations.

For sensitivity analyses, investigators considered outlier stations (i.e., stations likely having substantial numbers of riders beyond local residents). Collectively, the 68 Bronx stations had an average daily ridership of 397,341. Two stations alone (161st St., serving Yankee Stadium, and 3rd Ave-149th St., serving a local college and a retail, theater, and restaurant hub of the South Bronx) accounted for 11.3% of this figure. Each of these outlier stations had about four times the average ridership of the 66 other stations, and nearly twice the ridership (about 10,000 more daily riders) as the station with the next greatest daily ridership average. All analyses were run both with and without these outlier stations.

Other sensitivity analyses included consideration of ad exposure by total count, total surface area, proportion of count, and proportion of surface area, for all stations in the entire Bronx subway system ($n = 68$) and then also restricted only to those stations actually having ads ($n = 37$). All p values were nominal: no adjustments were made for multiple comparisons. Researchers performed all analyses in 2016 using Stata versions 12.1 and 14.1 (StataCorp LP, College Station, TX, USA)

Results

Table 1 shows that there were 1586 print ads in total; 284 were distinct across the entire subway system, and 1302 were duplicates. Some stations had as many as 15 copies of a given ad. Other stations ($n = 31$) had no

advertisements (e.g., stations adorned with mosaic tiles and art rather than advertising). In the 37 stations with advertising, three had only one ad, and the rest anywhere from 3 to 106 distinct ads (or as many as 226 ads counting duplicates).

Ads represented 146 companies, organizations, or brands. Most ads (84.9% of distinct ads, 89.7% of total ads) were for products or services other than foods or beverages (e.g., movies, music, television, theater, sporting events, museum exhibits, casinos, government programs, professional services, various schools and training programs, travel, tourism, and technology).

Advertisements specifically for foods or beverages appeared in most (73%) of the stations that had ads. There were no ads expressly promoting “more-healthy” food-or-beverage items. However, a few ads at least pictured some items that were “more-healthy” among other images—e.g., ads for online and storefront grocery sellers and for a Department of Education Summer Food Program. Ads promoting “less-healthy” items appeared in more stations than ads picturing any “more-healthy” items, and were more numerous by both distinct and total counts, both across the system and by station.

“Less-healthy” food items promoted in ads included candies, chips, sugary cereals, and frozen pizzas. “Less-healthy” beverages promoted in ads included “energy” drinks, coffee confections, hard alcohol, and beer. Beverage ads outnumbered food ads overall, and the vast majority were for alcohol. “Less-healthy” advertisements promoted products of the following brands: Archer Farms, Ben & Jerry’s, Budweiser, Bulldog, Coors Light, Dunkin’ Donuts, Kellogg’s, Market Pantry, Mike and Ike, Red Bull, Sapporo, Tic Tac, and Wise.

More than a third of the stations having advertising for “less-healthy” foods or beverages (39.1%) had such ads in Spanish (the only foreign language observed), more than a third (39.1%) had “less-healthy” ads featuring minorities, and greater than a quarter (26.1%) had less-healthy ads directed at youth.

Table 2 shows that ads for foods and beverages appeared disproportionately in stations in areas home to more vulnerable populations (i.e., areas with higher rates of poverty and higher percentages of Hispanics, non-Hispanic blacks, children, and adults not graduating high school). Differences were not statistically significant, except for “less-healthy” ads featuring minorities (which appeared disproportionately in residential areas home to greater percentages of children) and “less-healthy” ads in Spanish and directed at youth (which

Table 1 The number and type of print ads across the entire Bronx subway system, overall and by station (2012)

Type of print ads	Number of stations having any of the specified type of ads within the entire Bronx subway system, <i>n</i> (%)	Total distinct print ads within the Bronx subway system, <i>n</i> (%)	Total print ads (including duplicates) within the Bronx subway system, <i>n</i> (%)	Total distinct ads by station, excluding the 31 stations with no ads, <i>n</i> range (median)	Total ads (including duplicates) by station, excluding the 31 stations with no ads, <i>n</i> range (median)
(I) All print ads	37 (54.4) ^a	284 (100)	1586 (100)	1–106 (18)	1–226 (18)
(II) Food-or-beverage ads	27 (73.0)	43 (15.1)	163 (10.3)	0–12 (1)	0–34 (1)
(III) Picturing any more-healthy items ^b	16 (59.3)	12 (27.9)	52 (31.9)	0–5 (0)	0–16 (0)
(III) Promoting less-healthy items only	23 (85.2)	29 (67.4)	103 (63.2)	0–7 (1)	0–21 (1)
(IV) For food	14 (60.9)	12 (41.4)	40 (38.8)	0–5 (0)	0–9 (0)
(IV) For beverage	19 (82.6)	17 (58.6)	63 (61.2)	0–4 (1)	0–21 (1)
(V) For alcohol	17 (89.5)	12 (70.6)	39 (61.9)	0–4 (0)	0–9 (0)
(IV) Featuring minorities	9 (39.1)	3 (10.3)	15 (14.6)	0–2 (0)	0–5 (0)
(IV) In foreign language ^c	9 (39.1)	3 (10.3)	13 (12.6)	0–1 (0)	0–4 (0)
(IV) Directed at youth	6 (26.1)	6 (20.7)	13 (12.6)	0–4 (0)	0–4 (0)

% = percentage of the total count for the first row of the table and percentage of the count at the next-lower level of hierarchy (I – V) for all subsequent rows. For levels of hierarchy (I – V), I is the entire set, II is a subset of I, III is a subset of II, IV is a subset of III, and V is a subset of IV

^a 31 of the 68 subway stations in the Bronx had no ads (e.g., historic landmark stations adorned with mosaic tiles and art rather than advertising)

^b There were no ads expressly promoting “more-healthy” foods or beverages, although some ads at least contained images of more-healthy items (e.g., ads for online and storefront grocery sellers and ads for a Department of Education Summer Food Program)

^c The only foreign language observed in any ads was Spanish

were more likely to be in areas of higher poverty, having lower high-school graduation rates, and higher percentages of Hispanics and children).

Table 3 shows that ad placement did not relate to the number of riders entering each station in a statistically significant way and, if anything, there was an *inverse* relationship. Higher proportions of food-or-beverage ads were found not in stations with the most riders, but in stations surrounded by areas characterized by greater poverty, lower levels of educational attainment, and greater percentages of Hispanic residents. These stations also had a disproportionate share of “less-healthy” ads in Spanish or directed at youth, as did stations in areas home to higher percentages of children.

Appendix Tables 5, 6, 7, 8, and 9 show that exposure to food-or-beverage ads in subway stations generally, and exposure to “less-healthy” food-or-beverage ads particularly (specifically ads in Spanish, directed at youth, and/or featuring minorities), was directly correlated with poverty, lower high-school graduation rates, higher percentages of Hispanic residents, and/or higher percentages of children in surrounding residential areas. These associations tended to be statistically significant whether the measures of ad exposure were absolute (total ad number, total ad surface

area) or relative (proportion of total ads, proportion of total-ad surface area), or whether considering all stations in the system or only stations that actually had ads (regardless of inclusion or exclusion of stations that were outliers for ridership counts).

Table 4 shows that the proportion of ads for foods or beverages appearing in stations, and particularly the proportion of ads for “less-healthy” items directed at minorities, was directly correlated with sugary-drink consumption as well as diabetes, hypertension, and high-cholesterol rates in the residential areas surrounding stations. The proportion of ads for “less-healthy” items in general, and for alcohol specifically, was additionally correlated with the lower fruit-and vegetable consumption in surrounding areas.

Appendix Tables 10 and 12 show that absolute exposure (by count or surface area) to food-or-beverage ads, to ads for “less-healthy” items, to ads for alcohol, and to “less-healthy” ads directed at minorities were all only substantively correlated with sugary-drink consumption and high-cholesterol rates among examined diet and diet-related health outcomes. Appendix Tables 11 and 13 show that relative exposure (by proportion of surface area or proportion

Table 2 Number of Bronx stations having specific types of print ads and median percentages for demographics of the residential areas surrounding involved stations (2012)

Type of print ads	N stations ^b	Median percentage for demographics of the residential areas surrounding involved stations (and <i>p</i> values ^a)				
		Percent poverty	Percent not graduating high school	Percent non-Hispanic black	Percent Hispanic/Latino	Percent children
(I) All print ads	36	35.6	40.6	21.9	66.5	28.9
(II) Food-or-beverage ads	26	36.0 (0.15)	41.2 (0.13)	22.5 (0.29)	68.0 (0.10)	29.4 (0.08)
(III) For less- healthful items	22	37.0 (0.21)	41.8 (0.12)	22.4 (0.80)	67.1 (0.21)	29.4 (0.12)
(IV) For alcohol	17	36.3 (0.74)	41.6 (0.60)	23.0 (0.81)	65.5 (0.69)	29.3 (0.46)
(IV) Featuring minorities	9	38.5 (0.76)	42.5 (0.07)	23.3 (0.93)	69.6 (0.07)	30.0 (0.05)*
(IV) In Spanish	9	38.5 (0.02)*	42.5 (0.02)*	24.8 (0.25)	69.6 (0.02)*	30.0 (0.01)**
(IV) Directed at youth	6	39.3 (0.01)*	44.4 (0.00)**	24.0 (0.35)	72.1 (0.01)*	30.3 (0.02)*

“Residential areas” in this case were the census tracts containing each station along with any census tracts having borders within a ¼ mile of each station. For level of hierarchy (I–IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III

* $p < 0.05$, ** $p < 0.01$ (for actual *p* values as opposed to the *p* values rounded to two decimal places shown in the table)

^a *p* values were for Mann–Whitney *U* tests, testing the statistical significance of difference in the level of each demographic characteristic (between residential areas surrounding stations featuring the indicated type of ads vs. residential areas surrounding stations featuring all other types of ads)

^b Excluded were 31 stations having no ads (e.g., historic landmark stations adorned with mosaic tile and art rather than advertising), which included one high-traffic station serving various commercial attractions. Another high-traffic station, serving Yankee Stadium, was also excluded; results were not meaningfully different with its inclusion

of count) to these same ads was additionally correlated with low fruit-and-vegetable consumption, diabetes prevalence, and rates of hypertension. All of these correlations considered only stations having ads. When analysis included all stations within the system (i.e., also included stations

having no ads), there were no meaningful correlations (Appendix Table 14).

The Appendix Figure shows the Bronx, its subway lines, stations, surrounding areas, and ads. Panel A shows how ads, including ads for “less-healthful” items, were

Table 3 Spearman correlations, rho (and *p* value), between the proportion of ads appearing in Bronx stations, station ridership, and demographics of the residential areas surrounding stations (2012)

Type of print ads	Average daily ridership	Percent poverty	Percent not graduating high school	Percent non-Hispanic black	Percent Hispanic/Latino	Percent children
(I) All print ads (denominator)	–	–	–	–	–	–
(II) Food-or-beverage ads	–0.10 (0.54)	0.37 (0.03)*	0.35 (0.04)*	0.23 (0.19)	0.36 (0.03)*	0.26 (0.13)
(III) For less-healthful items	–0.29 (0.09)	0.26 (0.13)	0.25 (0.14)	–0.01 (0.94)	0.26 (0.12)	0.17 (0.32)
(IV) For alcohol	–0.27 (0.11)	0.05 (0.79)	0.10 (0.56)	0.07 (0.68)	0.09 (0.61)	0.09 (0.59)
(IV) Featuring minorities	–0.22 (0.20)	0.26 (0.13)	0.29 (0.09)	0.00 (0.99)	0.29 (0.08)	0.29 (0.09)
(IV) In Spanish	–0.14 (0.42)	0.37 (0.03)*	0.38 (0.02)*	0.17 (0.33)	0.39 (0.02)*	0.41 (0.01)*
(IV) Directed at youth	–0.05 (0.76)	0.42 (0.01)*	0.48 (0.00)**	0.13 (0.44)	0.44 (0.01)**	0.39 (0.02)*

“Residential areas” in this case were the census tracts containing each station along with any census tracts having borders within a ¼ mile of each station. For levels of hierarchy in this table (I–IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This primary analysis was restricted to the stations that both had ads ($n = 37$) and that did not serve major non-residential attractions with extreme-outlier values for ridership ($n = 1$), i.e., $n = 36$ stations. For analyses considering all stations and all ads, as well as ad exposure in both absolute and relative terms by both ad count and by ad surface area, please see Appendix Tables 5, 6, 7, 8, and 9.

* $p < 0.05$, ** $p < 0.01$ (for actual *p* values as opposed to the *p* values rounded to two decimal places shown in the table)

distributed throughout the subway system. Panel B shows the ¼-mile street-network buffers around each subway station, with gray-scale values for each area determined by aggregate population-weighted means of demographic characteristics (percent children in this case) for census tracts located within a ¼ mile. Panel C shows the five Bronx UHFs (in this case, with gray-scale values to represent diabetes rates). Inspection of panels B and C relative to panel A visually suggests correlations that were demonstrated statistically.

Discussion

For a large urban subway system, serving nearly 3 million riders per week, the current study demonstrated the extent of print advertising within stations. Although not all stations had ads, almost ¾ of those that did had ads for food or beverages, and the vast majority of these ads were for “less-healthy” items. Ads for “less-healthy” items tended to be in subway stations located in higher-risk residential areas—areas home to vulnerable populations facing diet and health-related challenges. Ad placement in stations did not correlate with subway rider counts but did correlate with socio-demographic characteristics. In other words, marketing of “less-healthy” foods and beverages was not directed towards the biggest audiences but appeared to be targeted to select groups. These findings are consistent with prior studies of advertising on mass transit and of print ads in communities more generally.

Prior studies have shown disproportionate placement of ads for alcohol in subway stations in high-poverty neighborhoods [8] with notable potential viewership among children [9]. The current study shows stations with alcohol ads—particularly alcohol ads in Spanish or featuring minorities—being located disproportionately in neighborhoods with greater poverty, lower educational attainment, higher percentages of black and Hispanic residents, and more children (not all data shown but available from the authors upon request).

In terms of ads for other beverages, and for food items, one prior study showed that outdoor ads for unhealthy items (those high in calories and low in nutrition) represented 18.9% of the total ad space in African American communities: a percentage more than twice that seen in white communities [6]. Latino communities, particularly those dense with young people, also showed disproportionate unhealthy-food advertising, and Latino communities with “multiple risks” (income insecurity, low-education, and high youth representation) had more than four times the

percentage of ads for “addictive behaviors” (e.g., alcohol) than white communities [6]. These results are consistent with the present study that showed “less-healthy” food-or-beverage ads—specifically those in Spanish, directed at youth, and/or featuring minorities—directly correlated with poverty, lower high-school graduation rates, higher percentages of Hispanic residents, and/or higher percentages of children in surrounding residential areas. Other research has shown that ads for “non-core foods” (foods surplus to daily nutritional requirements) as well as ads for sugary beverages and alcohol appear commonly around schools, especially in lower socio-economic areas [16] and black neighborhoods [7]. Lower-income and black communities are also more likely to have child-directed fast-food marketing—including on the exterior of fast-food restaurants—in school-enrollment areas [17].

All this advertising may influence behavior. For instance, exposure to outdoor alcohol advertising has been associated with subsequent intentions to use [18] and with problem drinking [19]. Lesser et al. showed that for every 10% increase in outdoor food advertising, there was a 5% greater odds of being overweight or obese, controlling for other factors [20]. While some outdoor food advertising occurs on the exteriors of food stores [21] and restaurants [17]—raising the possibility that it is the presence of food sources that matters for behavior rather than the advertising itself—the Lesser et al. study specifically excluded storefront ads [20], suggesting the particular and independent importance of other advertising in communities.

Ads in mass transit stations may be especially impactful as exposure might be sustained (as riders wait for trains) or recurrent (as riders repeat daily commutes). In the current study, presence of “less-healthy” food ads in stations (in general, or specifically directed at minorities) was correlated with the behaviors of lower fruit-and-vegetable consumption and higher sugary drink intake, and with diet-related conditions like diabetes, hypertension, and high cholesterol.

Investigators for the current study found no ads specifically promoting “healthy” food-or-beverage items. Even if ads containing images of more-healthy items (e.g., ads for grocery stores) could be counted as “healthy” ads, ads for “less-healthy” items were more abundant in all but five stations.

There were some ads that contained images or references to foods or beverages, which were not specifically promoting food-or-beverage items and which researchers did not count as “food-or-beverage ads” to be conservative (e.g., a *Cash Blast* lottery ad with tag line “Drink soda, burp Champagne,” a jetBlue airline ad stating “from the

Table 4 Spearman correlations, rho (and *p* value), between the proportion of Bronx station ads appearing in residential areas and the diet and diet-related health characteristics of those residential areas (2012)

Type of print ads	Percent consuming no fruits or vegetables yesterday		Percent consuming 1 or more sugary drink per day on average		Percent obese (BMI >30)		Percent ever told by healthcare provide they have diabetes		Percent taking medicine for high blood pressure		Percent taking medicine for cholesterol	
(I) All print ads (denominator)	—		—		—		—		—		—	
(II) Food-or-beverage ads	0.40	(0.60)	1.00	(0.00)**	0.20	(0.80)	0.80	(0.20)*	0.80	(0.20)*	1.00	(0.00)**
(III) For less-healthy items	0.80	(0.20)*	0.80	(0.20)*	0.40	(0.60)	1.00	(0.00)**	1.00	(0.00)**	0.80	(0.20)*
(IV) For alcohol	0.80	(0.20)*	0.80	(0.20)*	0.40	(0.60)	1.00	(0.00)**	1.00	(0.00)**	0.80	(0.20)*
(IV) Featuring minorities	0.40	(0.60)	1.00	(0.00)**	0.20	(0.80)	0.80	(0.20)*	0.80	(0.20)*	1.00	(0.00)**
(IV) In Spanish	−0.11	(0.90)	0.63	(0.37)	0.21	(0.79)	0.11	(0.90)	0.11	(0.90)	0.63	(0.37)
(IV) Directed at youth	0.11	(0.90)	0.21	(0.79)	0.63	(0.37)	−0.11	(0.90)	−0.11	(0.90)	0.21	(0.79)

"Residential areas" in this case were the United Hospital Fund areas (UHFs). For levels of hierarchy in this table (I–IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This primary analysis was restricted to the four UHFs that had stations with ads; a 5th UHF contained only stations with no ads; analysis was also restricted to ads in stations not serving major non-residential attractions. For analyses considering all ads in all stations and all residential areas (UHFs), as well as exposure in absolute and relative terms by both ad count and by ad surface area, please see Appendix Tables 10, 11, 12, 13, and 14.

*Noteworthy correlation; imprecision in estimate (high *p* value) artifact of few data points; **perfect correlation between a small number of data points

Apple to oranges" to announce service from New York City to Florida, and an ad for the movie "ted" showing a beer-drinking teddy bear). These ads would have tended to exacerbate found disparities.

The current study had several strengths. It is the first to evaluate food-and-beverage advertising in mass transit. The sampling frame included all ads in all stations of an entire subway system in a large urban county. Statistics considered associations with demographic, diet, and diet-related health factors, and there were extensive sensitivity analyses.

Limitations of the current study include the cross-sectional design. Ad space is generally sold in 4-week increments so the presence and proportion of ads can vary month-to-month. Also, while station-entry numbers and features of surrounding areas can suggest information about subway riders, actual ridership (exactly who got on and off at each station) was not known. It is likely, though, that the official ridership counts underestimated total entry at each station due to people bypassing turnstiles—legally (e.g., young children) and illegally (i.e., fare dodgers). Regardless, not every rider might see every ad in a given station—irrespective of variable wait times—so analyses here are based on potential rather than actual exposure. Potential exposure included only ads in stations of entry (or exit), not ads that might be glimpsed in passing through other stations while riding trains, or additional ads on trains themselves.

In spite of limitations, findings in the current study are consistent with associations reported from prior research, in different cities and in other public settings.

It appears that placement of print ads in subway stations (as elsewhere) represents targeted marketing: in this case, the promotion of "unhealthy items to vulnerable groups. Of course, in the Bronx situation, it is possible that all other companies and organizations advertising in the subway system specifically targeted healthy, wealthy, highly educated, English-speaking, native-born, white adults, so that the only ad space remaining for "less-healthy" food companies to occupy was in neighborhoods home to low-income minorities and children. This scenario seems unlikely and makes it unlikely that any patterned distribution was due to chance. Given that it costs advertisers considerably more (66.7% more, in fact, per personal communication with the MTA's sales department) to select specific stations than for random distribution of ads in the system, targeting to select communities comes at a premium.

As to solutions, voluntary restrictions and pledges by industry to eliminate ads to select groups (e.g., ads to children) have historically been ineffective [22, 23]. Community activists could inspire government's action to regulate allowable areas for allowable advertising [24], but outdoor ads are so ubiquitous (occurring on free-standing billboards, on sidewalk signs, on banners, flags, posters, painted on the sides of buildings, posted in windows, on bus benches and shelters [5, 7, 20] ... not to mention on and in transit vehicles themselves) that to restrict station ads alone might do little to limit total exposure.

Then again, the MTA already does have standards for what ads can appear in and on its facilities, vehicles, and other property [25]. The current standards have more to do with decency, obscenity, and legality of products than public health or prevention concerns, but advertising for at least one “unhealthful” item is explicitly prohibited: tobacco. Perhaps restrictions on “unhealthful” food and beverage advertising could follow a similar model. However, a sticking point would almost certainly be defining what constitutes “unhealthful” with regard to food and beverages, a matter about which even nutrition experts might disagree [26], and which foreseeably could become the subject of litigation.

In the interim, shining light on the issue of “unhealthful” food and beverage advertising—to empower seemingly targeted groups to advocate for themselves and hold companies accountable—could be part of the solution. Potential consumers might choose to avoid products of offending brands and companies. Studies like the current one can help in this regard.

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Appendix

UHF = United Hospital Fund area

Appendix Figure. The Bronx, its subway lines, stations, surrounding areas, and ads (2012).

Table 5 Spearman correlations, rho (and *p* value), between the number of ads appearing in stations, station ridership, and demographics of the residential areas surrounding stations

Type of print ads	Average daily ridership		Percent poverty		Percent not graduating high school		Percent non-Hispanic black		Percent Hispanic/Latino		Percent children	
(I) All print ads	0.00	(0.994)	0.29	(0.082)	0.34	(0.045)*	0.19	(0.255)	0.28	(0.098)	0.42	(0.011)*
(II) Food-or-beverage ads	-0.06	(0.746)	0.35	(0.039)*	0.36	(0.032)*	0.20	(0.237)	0.31	(0.063)	0.39	(0.019)*
(III) For less-healthy items	-0.19	(0.279)	0.29	(0.081)	0.32	(0.054)	0.08	(0.644)	0.25	(0.143)	0.31	(0.066)
(IV) For alcohol	-0.25	(0.148)	0.15	(0.375)	0.16	(0.356)	0.11	(0.527)	0.14	(0.408)	0.19	(0.256)
(IV) Featuring minorities	-0.19	(0.260)	0.32	(0.061)	0.34	(0.044)*	0.03	(0.849)	0.32	(0.055)	0.35	(0.035)
(IV) In Spanish	-0.14	(0.421)	0.40	(0.016)*	0.40	(0.016)*	0.19	(0.267)	0.39	(0.018)*	0.44	(0.007)*
(IV) Directed at youth	0.01	(0.971)	0.41	(0.013)*	0.49	(0.003)**	0.16	(0.360)	0.41	(0.014)*	0.41	(0.013)*

"Residential areas" in this case were the census tracts containing each station along with any census tracts having borders within a ¼ mile of each station. For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis was restricted to the stations that had ads ($n = 37$) but that did not serve major non-residential attractions with extreme-outlier values for ridership ($n = 1$), i.e., $n = 36$ stations.

* $p < 0.05$, ** $p < 0.01$ (for actual p values as opposed to the p values rounded to two decimal places shown in the table)

Table 6 Spearman correlations, rho (and *p* value), between the proportion of surface area of ads appearing in stations, station ridership, and demographics of the residential areas surrounding stations

Type of print ads	Average daily ridership		Percent poverty		Percent not graduating high school		Percent non-Hispanic black		Percent Hispanic/Latino		Percent children	
(I) All print ads	—		—		—		—		—		—	
(II) Food-or-beverage ads	-0.14	(0.402)	0.34	(0.043)*	0.36	(0.031)*	0.21	(0.214)	0.34	(0.045)*	0.25	(0.149)
(III) For less-healthy items	-0.31	(0.070)	0.28	(0.098)	0.28	(0.095)	0.00	(0.997)	0.28	(0.097)	0.20	(0.234)
(IV) For alcohol	-0.30	(0.080)	0.07	(0.700)	0.12	(0.489)	0.08	(0.663)	0.11	(0.521)	0.11	(0.519)
(IV) Featuring minorities	-0.22	(0.200)	0.27	(0.117)	0.29	(0.084)	0.01	(0.961)	0.30	(0.074)	0.30	(0.078)
(IV) In Spanish	-0.15	(0.384)	0.36	(0.029)*	0.38	(0.021)*	0.18	(0.302)	0.38	(0.020)*	0.41	(0.013)*
(IV) Directed at youth	-0.05	(0.762)	0.42	(0.011)*	0.48	(0.003)**	0.13	(0.442)	0.44	(0.008)**	0.39	(0.018)*

"Residential areas" in this case were the census tracts containing each station along with any census tracts having borders within a ¼ mile of each station. For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis was restricted to the stations that had ads ($n = 37$) but that did not serve major non-residential attractions with extreme-outlier values for ridership ($n = 1$), i.e., $n = 36$ stations.

* $p < 0.05$, ** $p < 0.01$ (for actual p values as opposed to the p values rounded to two decimal places shown in the table)

Table 7 Spearman correlations, rho (and *p* value), between the total surface area of ads appearing in stations, station ridership, and demographics of the residential areas surrounding stations

Type of print ads	Average daily ridership		Percent poverty		Percent not graduating high school		Percent non-Hispanic black		Percent Hispanic/Latino		Percent children	
(I) All print ads	0.02	(0.893)	0.31	(0.069)	0.33	(0.052)	0.17	(0.319)	0.29	(0.081)	0.40	(0.016)*
(II) Food-or-beverage ads	-0.10	(0.578)	0.33	(0.050)*	0.36	(0.030)*	0.20	(0.249)	0.29	(0.091)	0.38	(0.023)*
(III) For less-healthy items	-0.21	(0.218)	0.28	(0.092)	0.33	(0.053)	0.10	(0.570)	0.24	(0.162)	0.31	(0.069)
(IV) For alcohol	-0.26	(0.131)	0.15	(0.391)	0.16	(0.365)	0.11	(0.526)	0.14	(0.417)	0.19	(0.273)
(IV) Featuring minorities	-0.20	(0.254)	0.32	(0.061)	0.34	(0.044)*	0.03	(0.856)	0.32	(0.054)	0.35	(0.037)
(IV) In Spanish	-0.16	(0.350)	0.39	(0.018)*	0.39	(0.018)*	0.19	(0.271)	0.39	(0.020)*	0.43	(0.009)**
(IV) Directed at youth	0.00	(0.984)	0.41	(0.013)*	0.49	(0.003)**	0.16	(0.367)	0.41	(0.013)**	0.40	(0.014)*

"Residential areas" in this case were the census tracts containing each station along with any census tracts having borders within a ¼ mile of each station. For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis was restricted to the stations that had ads ($n = 37$) but that did not serve major non-residential attractions with extreme-outlier values for ridership ($n = 1$), i.e., $n = 36$ stations.

* $p < 0.05$, ** $p < 0.01$ (for actual p values as opposed to the p values rounded to two decimal places shown in the table)

Table 8 Spearman correlations, rho (and *p* value), between the proportion of ads appearing in stations, station ridership, and demographics of the residential areas surrounding stations

Type of print ads	Average daily ridership		Percent poverty		Percent not graduating high school		Percent non-Hispanic black		Percent Hispanic/Latino		Percent children	
(I) All print ads	–		–		–		–		–		–	
(II) Food-or-beverage ads	–0.02	(0.908)	0.32	(0.056)	0.32	(0.055)	0.27	(0.106)	0.32	(0.050)*	0.21	(0.223)
(III) For less-healthy items	–0.19	(0.272)	0.21	(0.217)	0.22	(0.199)	0.04	(0.798)	0.23	(0.175)	0.12	(0.467)
(IV) For alcohol	–0.30	(0.074)	0.05	(0.771)	0.10	(0.551)	0.03	(0.854)	0.09	(0.587)	0.11	(0.518)
(IV) Featuring minorities	–0.23	(0.163)	0.26	(0.121)	0.29	(0.084)	–0.02	(0.888)	0.29	(0.076)	0.30	(0.075)
(IV) In Spanish	–0.16	(0.350)	0.37	(0.023)*	0.38	(0.020)*	0.13	(0.429)	0.39	(0.016)*	0.42	(0.010)**
(IV) Directed at youth	–0.07	(0.680)	0.42	(0.010)*	0.48	(0.003)**	0.11	(0.507)	0.44	(0.007)**	0.40	(0.015)*

“Residential areas” in this case were the census tracts containing each station along with any census tracts having borders within a ¼ mile of each station. For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis was restricted to the 37 of 68 stations that actually had ads (which included one station that served a major non-residential attraction: Yankee Stadium).

* $p < 0.05$, ** $p < 0.01$ (for actual *p* values as opposed to the *p* values rounded to two decimal places shown in the table)

Table 9 Spearman correlations, rho (and *p* value), between the number of ads appearing in stations, station ridership, and demographics of the residential areas surrounding stations

Type of print ads	Average daily ridership		Percent poverty		Percent not graduating high school		Percent non-Hispanic black		Percent Hispanic/Latino		Percent children	
(I) All print ads	0.05	(0.687)	0.22	(0.076)	0.24	(0.046)*	–0.27	(0.024)*	0.31	(0.010)*	0.20	(0.110)
(II) Food-or-beverage ads	0.07	(0.586)	0.25	(0.038)*	0.28	(0.022)*	–0.16	(0.188)	0.32	(0.008)**	0.23	(0.061)
(III) For less-healthy items	–0.03	(0.816)	0.21	(0.080)	0.25	(0.039)*	–0.19	(0.129)	0.27	(0.026)*	0.20	(0.106)
(IV) For alcohol	–0.16	(0.193)	0.14	(0.269)	0.16	(0.200)	–0.18	(0.151)	0.20	(0.103)	0.15	(0.209)
(IV) Featuring minorities	–0.13	(0.283)	0.24	(0.048)*	0.26	(0.033)*	–0.13	(0.276)	0.29	(0.017)*	0.27	(0.028)*
(IV) In Spanish	–0.09	(0.466)	0.30	(0.012)*	0.32	(0.009)**	–0.04	(0.763)	0.34	(0.005)**	0.34	(0.004)**
(IV) Directed at youth	–0.02	(0.878)	0.31	(0.011)*	0.37	(0.002)**	–0.03	(0.782)	0.34	(0.005)**	0.31	(0.009)**

“Residential areas” in this case were the census tracts containing each station along with any census tracts having borders within a ¼ mile of each station. For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis included all 68 Bronx subway stations (the 37 stations that had ads and the 31 stations that had no ads).

* $p < 0.05$, ** $p < 0.01$ (for actual *p* values as opposed to the *p* values rounded to two decimal places shown in the table)

Table 10 Spearman correlations, rho (and *p* value), between the number of station ads appearing in residential areas and the diet and diet-related health characteristics of those residential areas

Type of print ads	Percent consuming no fruits or vegetables yesterday		Percent consuming 1 or more sugary drink per day on average		Percent obese (BMI >30)		Percent ever told by healthcare provider they have diabetes		Percent taking medicine for high blood pressure		Percent taking medicine for cholesterol	
(I) All print ads	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(II) Food-or-beverage ads	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(III) For less-healthy items	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(IV) For alcohol	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(IV) Featuring minorities	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(IV) In Spanish	–0.11	(0.895)	0.63	(0.368)	0.21	(0.789)	0.11	(0.895)	0.11	(0.895)	0.63	(0.368)
(IV) Directed at youth	–0.11	(0.895)	0.63	(0.368)	0.21	(0.789)	0.11	(0.895)	0.11	(0.895)	0.63	(0.368)

“Residential areas” in this case were the United Hospital Fund areas (UHFs). For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis was restricted to the four UHFs that had stations with ads; a 5th UHF contained only stations with no ads; analysis was also restricted to ads in stations not serving major non-residential attractions.

*Noteworthy correlation; imprecision in estimate (high *p* value) artifact of few data points; **perfect correlation between a small number of data points

Table 11 Spearman correlations, rho (and *p* value), between the proportion of total surface area of station ads appearing in residential areas and the diet and diet-related health characteristics of those residential areas

Type of print ads	Percent consuming no fruits or vegetables yesterday		Percent consuming 1 or more sugary drink per day on average		Percent obese (BMI >30)		Percent ever told by healthcare provide they have diabetes		Percent taking medicine for high blood pressure		Percent taking medicine for cholesterol	
(I) All print ads	–		–		–		–		–		–	
(II) Food-or-beverage ads	0.40	(0.600)	1.00	(<0.001)**	0.20	(0.800)	0.80	(0.200)*	0.80	(0.200)*	1.00	(<0.001)**
(III) For less-healthy items	0.80	(0.200)*	0.80	(0.200)*	0.40	(0.600)	1.00	(<0.001)**	1.00	(<0.001)**	0.80	(0.200)*
(IV) For alcohol	0.80	(0.200)*	0.80	(0.200)*	0.40	(0.600)	1.00	(<0.001)**	1.00	(<0.001)**	0.80	(0.200)*
(IV) Featuring minorities	0.40	(0.600)	1.00	(<0.001)**	0.20	(0.800)	0.80	(0.200)*	0.80	(0.200)*	1.00	(<0.001)**
(IV) In Spanish	–0.11	(0.895)	0.63	(0.368)	0.21	(0.789)	0.11	(0.895)	0.11	(0.895)	0.63	(0.368)
(IV) Directed at youth	0.11	(0.895)	0.21	(0.789)	0.63	(0.368)	–0.11	(0.895)	–0.11	(0.895)	0.21	(0.789)

“Residential areas” in this case were the United Hospital Fund areas (UHF). For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis was restricted to the four UHF that had stations with ads; a 5th UHF contained only stations with no ads; analysis was also restricted to ads in stations not serving major non-residential attractions.

*Noteworthy correlation; imprecision in estimate (high *p* value) artifact of few data points; **perfect correlation between a small number of data points

Table 12 Spearman correlations, rho (and *p* value), between the total surface area of station ads appearing in residential areas and the diet and diet-related health characteristics of those residential areas

Type of print ads	Percent consuming no fruits or vegetables yesterday		Percent consuming 1 or more sugary drink per day on average		Percent obese (BMI >30)		Percent ever told by healthcare provide they have diabetes		Percent taking medicine for high blood pressure		Percent taking medicine for cholesterol	
(I) All print ads	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(II) Food-or-beverage ads	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(III) For less-healthy items	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(IV) For alcohol	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(IV) Featuring minorities	0.20	(0.800)	0.80	(0.200)*	0.40	(0.600)	0.40	(0.600)	0.40	(0.600)	0.80	(0.200)*
(IV) In Spanish	–0.11	(0.895)	0.63	(0.368)	0.21	(0.789)	0.11	(0.895)	0.11	(0.895)	0.63	(0.368)
(IV) Directed at youth	–0.11	(0.895)	0.63	(0.368)	0.21	(0.789)	0.11	(0.895)	0.11	(0.895)	0.63	(0.368)

“Residential areas” in this case were the United Hospital Fund areas (UHF). For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis was restricted to the four UHF that had stations with ads; a 5th UHF contained only stations with no ads; analysis was also restricted to ads in stations not serving major non-residential attractions.

*Noteworthy correlation; imprecision in estimate (high *p* value) artifact of few data points; **perfect correlation between a small number of data points

Table 13 Spearman correlations, rho (and *p* value), between the proportion of all station ads appearing in residential areas and the diet and diet-related health characteristics of those residential areas

Type of print ads	Percent consuming no fruits or vegetables yesterday		Percent consuming 1 or more sugary drink per day on average		Percent obese (BMI >30)		Percent ever told by healthcare provide they have diabetes		Percent taking medicine for high blood pressure		Percent taking medicine for cholesterol	
(I) All print ads	–		–		–		–		–		–	
(II) Food-or-beverage ads	0.40	(0.600)	1.00	(<0.001)**	0.20	(0.800)	0.80	(0.200)*	0.80	(0.200)*	1.00	(<0.001)**
(III) For less-healthy items	0.80	(0.200)*	0.80	(0.200)*	0.40	(0.600)	1.00	(<0.001)**	1.00	(<0.001)**	0.80	(0.200)*
(IV) For alcohol	0.80	(0.200)*	0.80	(0.200)*	0.40	(0.600)	1.00	(<0.001)**	1.00	(<0.001)**	0.80	(0.200)*
(IV) Featuring minorities	0.40	(0.600)	1.00	(<0.001)**	0.20	(0.800)	0.80	(0.200)*	0.80	(0.200)*	1.00	(<0.001)**
(IV) In Spanish	–0.11	(0.895)	0.63	(0.368)	0.21	(0.789)	0.11	(0.895)	0.11	(0.895)	0.63	(0.368)
(IV) Directed at youth	0.11	(0.895)	0.21	(0.789)	0.63	(0.368)	–0.11	(0.895)	–0.11	(0.895)	0.21	(0.789)

Residential areas in this case were the United Hospital Fund areas (UHF). For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis was restricted to the four UHF that had stations with ads; a 5th UHF contained only stations with no ads.

*Noteworthy; imprecision in estimate (high *p* value) artifact of few data points; **perfect correlation between a small number of data points

Table 14 Spearman correlations, rho (and *p* value), between the number of ads appearing in Bronx subway stations and the diet and diet-related health characteristics of those residential areas

Type of print ads	Percent consuming no fruits or vegetables yesterday	Percent consuming 1 or more sugary drink per day on average	Percent obese (BMI >30)	Percent ever told by healthcare provide they have diabetes	Percent taking medicine for high blood pressure	Percent taking medicine for cholesterol
(I) All print ads	0.10 (0.873)	0.30 (0.624)	0.00 (1.000)	0.30 (0.624)	−0.10 (0.873)	0.30 (0.624)
(II) Food-or-beverage ads	0.21 (0.741)	0.46 (0.434)	0.15 (0.805)	0.41 (0.493)	0.05 (0.935)	0.46 (0.434)
(III) For less-healthy items	0.21 (0.741)	0.46 (0.434)	0.15 (0.805)	0.41 (0.493)	0.05 (0.935)	0.46 (0.434)
(IV) For alcohol	0.21 (0.741)	0.46 (0.434)	0.15 (0.805)	0.41 (0.493)	0.05 (0.935)	0.46 (0.434)
(IV) Featuring minorities	0.21 (0.741)	0.46 (0.434)	0.15 (0.805)	0.41 (0.493)	0.05 (0.935)	0.46 (0.434)
(IV) In Spanish	−0.11 (0.858)	0.45 (0.450)	0.11 (0.858)	0.11 (0.858)	−0.22 (0.718)	0.45 (0.450)
(IV) Directed at youth	−0.11 (0.858)	0.45 (0.450)	0.11 (0.858)	0.11 (0.858)	−0.22 (0.718)	0.45 (0.450)

“Residential areas” in this case were the United Hospital Fund areas (UHFs). For levels of hierarchy in this table (I - IV), I is the entire set, II is a subset of I, III is a subset of II, and IV is a subset of III. This analysis included the all five UHFs in the Bronx; the four with stations having ads and the one with stations having no ads.

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