Health & Place ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Clustering of unhealthy outdoor advertisements around child-serving institutions: A comparison of three cities

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ARTICLE INFO

Article history:
Received 7 August 2008
Received in revised form
22 February 2009
Accepted 26 February 2009

Keywords:
Outdoor advertising
Child-serving institutions
Geographic information systems
Land use regulations
Los Angeles
Philadelphia

ABSTRACT

Using GPS devices and digital cameras, we surveyed outdoor advertisements in Austin, Los Angeles and Philadelphia. GIS and hot spot analysis revealed that unhealthy ads were clustered around child-serving institutions in Los Angeles and Philadelphia but not in Austin. Multivariate generalized least square (GLS) regression models showed that percent black ($p<0.04$) was a significant positive predictor of clustering in Philadelphia and percent white ($p<0.06$) was a marginally significant negative predictor of clustering in Los Angeles after controlling for several land use variables. The results emphasize the importance of zoning and land use regulations to protect children from exposure to unhealthy commercial messages, particularly in neighborhoods with significant racial/ethnic minority populations.

Introduction

Investigators are increasingly taking note of the influence of the built and social environments in their efforts to explain and address the widening disparities in health outcomes across racial, ethnic, and income groups (Northbridge et al., 2003). Obesity, heart disease, and diabetes are among the many health problems that disproportionately affect people of color and people living in poverty (National Center for Health Statistics, 2007; Kumanyika and Grier, 2006). Ecological models are useful because they incorporate differences in neighborhoods where racial and ethnic minorities and low-income people live as determinants of differences in health outcomes (Davison and Birch, 2001; Cohen et al., 2000; Diez-Roux, 1998). In an ecological framework, racial and economic segregation are hypothesized to help to explain differences in health outcomes (Kwate, 2008; Chang, 2006; Kawachi and Berkman, 2003; Williams and Collins, 2001). Given the environmental factors that shape choices and behaviors, interventions aimed at individual behavior change must be complemented by changes in the environments in which people live and work in order to positively influence health behaviors and outcomes (Swinburn et al., 1997; Hinkle, 1997; King et al., 1995).

Previous studies have investigated how access to grocery stores, fast-food restaurants, alcoholic beverages, and tobacco products differs by neighborhood racial or ethnic composition and household income (Powell et al., 2007c; Zenk et al., 2005; Horowitz et al., 2004; Morland et al., 2002b; Sloane et al., 2003; Grier et al., 2007; Lewis et al., 2005; Block et al., 2004), with special attention to the environment around schools where children are especially vulnerable because of repeated exposure (Kelly et al., 2008; Pasch et al., 2008; Scott et al., 2008; Sturm, 2008; Pasch et al., 2007; Austin et al., 2006). Relatively little research, however, has looked at how differences in outdoor advertising relate to neighborhood demographic and health outcomes despite the strong evidence linking marketing to consumption (Pasch et al., 2007; Institute of Medicine, 2006; Hastings et al., 2003) and the enormous sums—$8 billion annually—spent on outdoor commercial advertising

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doi:10.1016/j.healthplace.2009.02.014

(Macklin, 2007). Furthermore, the power of advertisements to shape the environment, or "transform the landscape" (Law, 1997), suggests that concentrations of ads in geographic areas defined by certain sociodemographic characteristics deserve special attention in the study of health disparities.

This paper uses geographic information systems (GISs) and spatial statistical analyses to assess the location and content of outdoor advertisements in Austin, Los Angeles, and Philadelphia in order to answer four research questions: (1) Do unhealthy ads cluster around institutions that serve children, including schools, day-care facilities, recreation centers, and libraries? (2) Are unhealthy outdoor advertisements more likely to be clustered around child-serving institutions in racial/ethnic minority and low-income areas? (3) Do land use patterns account for differences in clustering by neighborhood racial/ethnic and income composition? And (4) Do the spatial patterns of unhealthy ads vary by city?

Background

Research on health disparities in the United States increasingly points to the greater prevalence of unhealthy foods, products, and advertising and lesser availability of healthy resources in neighborhoods with significant low-income and racial/ethnic minority populations (Grier et al., 2007; Lewis et al., 2005; Powell et al., 2007c; Zenk et al., 2005; Block et al., 2004; Horowitz et al., 2004; Sloane et al., 2003; Morland et al., 2002b). Research in the United Kingdom, Australia, and New Zealand has found very different patterns (Crawford et al., 2008; Pearce et al., 2007, 2008; Cummins and MacIntyre, 2006), but studies in the US have consistently shown that neighborhoods with significant low-income and racial/ethnic minority populations have fewer supermarkets and convenience stores that stock fresh, high-quality, affordable foods and healthy products (Powell et al., 2007c; Zenk et al., 2005; Horowitz et al., 2004; Morland et al., 2002b; Sloane et al., 2003) and more fast-food restaurants (Grier et al., 2007; Lewis et al., 2005; Block et al., 2004). Some studies have linked greater access to supermarkets to healthier eating (Laraia et al., 2004; Rose and Richards, 2004; Morland et al., 2002a; Cheadle et al., 1993), lower BMI among adolescents (Powell et al., 2007a), and lower likelihood of low birth-weight births (Lane et al., 2007), while others have linked greater access to take-out restaurants to higher BMI among adults (Mehta and Chang, 2008).

Researchers have also found that predominantly low-income and ethnic minority neighborhoods have fewer parks and recreation facilities (Taylor et al., 2006; Powell et al., 2004; Wolch et al., 2004; Estabrooks et al., 2003). Several studies have also shown that greater access to parks and recreation facilities predict greater levels of physical activity (Powell et al., 2007b; Norman. et al., 2006; Sallis et al., 2000). In addition, while communities with significant urban low-income and/or racial/ethnic minority populations are generally more "walkable"—as defined by such parameters as population density, street width, street interconnectivity, and block length—perceptions of safety and walking prevalence are both low (Day, 2006). Predominantly low-income and racial/ethnic minority neighborhoods also tend to have more alcohol outlets (Romley et al., 2007; LaVeist and Wallace, 2000), which is a societal concern because research has linked alcohol outlet density to drinking (Treno et al., 2003), drinking and driving (Gruenewald et al., 1996), child maltreatment (Freisthler et al., 2007, 2004), car accidents (Gruenewald et al., 1996), and violence (Gruenewald and Remer, 2006; Gorman et al., 2001; Gruenewald et al., 1996, 2006; Scribner et al., 1995).

Research on racial/ethnic disparities in outdoor advertising has generated similar results. African-American and Hispanic neighborhoods have greater exposure to outdoor advertisements, particularly for alcoholic beverages and tobacco products, even when controlling for household income (Kwate and Lee, 2007; Hackbarth et al., 1995; Stoddard et al., 1998; Altman et al., 1991). Studies have found that advertisers specifically target racial/ethnic minorities (Hacker et al., 1987; Moore et al., 1996), including youth (Williams et al., 1993; Maxwell and Jacobson 1989). Another study from our research group found that ads for unhealthy foods and products promoting sedentary behavior were more concentrated in low-income and ethnic minority zip codes. Ads depicting physical activity were scarce in any neighborhood, but 36% of these health-promoting ads were in high-income white zip codes (Yancey et al., 2009).

Examining the consequences of these environmental disparities, a growing body of literature has focused specifically on aspects of the environment surrounding schools. Daily exposure to health-compromising influences has a particularly deleterious impact on youth because of their vulnerable life stage (Pasch et al., 2007). This includes research about crime and physical safety as it relates to walking or biking to school (Ahlport et al., 2007; Klifton and Kreamer-Fults, 2007; Falb et al., 2007; Boarnet et al., 2005; Staunton et al., 2003), noise (Thakur, 2006), and clustering of fast-food restaurants, conveniences stores, tobacco retailers (Novak et al., 2006), and alcohol outlets (Sturm, 2008; Austin et al., 2006). Several studies have also documented that areas around schools have a disproportionate number of unhealthy outdoor advertisements, particularly for alcoholic beverages and tobacco products (Morland et al., 2002b; Hackbarth et al., 1995; Luke et al., 2000; Alaniz and Wilkes, 1995). Combining a focus on schools and ethnicity, Pasch et al. (2008) found that schools with 20% or more Hispanic students were exposed to 6.5 times more alcohol advertising around their school than students with less than 20% Hispanic students.

Taking this one step further, researchers have documented a connection between exposure to advertisements for alcoholic beverages and adolescent attitudes and behavior related to drinking. Snyder et al. (2006) found that greater exposure to television advertisements was correlated with drinking more alcoholic beverages. Fleming et al. (2004) found that magazine advertisements, radio and television commercials, and billboards advertising alcoholic beverages were associated with more positive adolescent attitudes and perceptions about drinking alcohol. Most recently, Pasch et al. (2007) found that sixth grade children exposed to alcohol advertisements within 1500 ft of their schools had more positive attitudes and behaviors about drinking when they reached the eighth grade. Novak et al. (2006) found that youth living in areas with higher concentrations of tobacco outlets were more likely to smoke. Tobacco advertisements in magazines have also been shown to impact adolescent attitudes about smoking and likelihood of experimenting with cigarettes or becoming a smoker (Aloise-Young et al., 2006; Lovata et al., 2003).

This study was designed to build on research investigating the role that geographic disparities may play in explaining observed disparities in health outcomes by examining spatial patterns in unhealthy outdoor advertisements. A strength of this study is that it compares these patterns across three different cities—Austin, Los Angeles, and Philadelphia—to determine whether spatial and demographic patterns in outdoor ads are similar across cities. We consider a broader range of "unhealthy" advertisements—alcoholic beverages, tobacco products, sugary beverages, and fast-food restaurants—than in previous research because we are concerned about a range of possible negative health behaviors and outcomes, including physical inactivity, obesity, violence, and drinking. Looking at just one of these categories in isolation would provide only a limited perspective on children's exposure to unhealthy products and would limit the sample size of advertisements for analysis. We also considered a broader range of child-serving institutions—day-care centers, libraries, recreation centers, and schools—than previous studies because schools are only one of the many places where children spend time and might be especially vulnerable to advertising messages. We also give special attention to the role of land use patterns as a possible alternative explanation to one that assumes deliberate targeting of neighborhoods based on racial/ethnic and income composition.

Based on previous research, our hypotheses were that: (1) outdoor advertisements for unhealthy products would cluster around child-serving institutions; (2) clustering would be more likely in racial/minority and low-income areas; (3) land use patterns would not fully account for this clustering; and (4) the content and spatial distribution of advertisements would not vary significantly across the three cities.

Study background

The California Department of Health Services' California Nutrition Network for Healthy, Active Families commissioned researchers at the University of California at Los Angeles (UCLA) to examine whether there was any association between the demographic characteristics of neighborhoods and the outdoor advertisements that could be found in these neighborhoods for high-fat, high-sugar foods and beverages and/or products promoting a sedentary lifestyle. The study was subsequently expanded to include researchers at the University of Texas (Austin), University of Pennsylvania (Philadelphia), California State University at Fresno, and University of California at Davis and included analysis of both outdoor and magazine advertisements.

Zip code areas representing high- and low-income areas that were predominantly African American, Latino, and white were selected within each city for analysis. "High income" was defined as being above the city's median household income according to the 2000 US Census and "low income" was defined as below the median income. "Predominantly" African American, Latino, or white was defined as more than 50% of residents, based on the 2000 US Census. There was no high-income Latino area in Philadelphia. In Los Angeles, the high-income white zip code area selected was found to have no outdoor ads; so it was left out of the analysis to avoid statistical problems determining averages and regression coefficients created by a zero or near-zero dependent variable. In Austin, nine zip code areas were selected, including a high, low, and moderate (approximately median) income area for each race/ethnic category.

Results from our analysis of advertisements in all five cities cited earlier are published elsewhere (Yancey et al., 2009). Results presented in this paper relate only to the spatial distribution of outdoor advertisements in Austin, Los Angeles, and Philadelphia.

Regulatory environment for outdoor advertising

With the exception of the federal Highway Beautification Act of 1965, which regulates signs adjacent to federal interstate highways, regulation of outdoor advertising falls under the jurisdiction of local governments. Different local zoning codes, ordinances, and agreements with outdoor advertisers contribute to very different regulatory environments in each of the three cities included in the study.

Austin regulatory environment

Current regulations of outdoor advertising in Austin are based primarily on a 1983 ordinance that banned construction of any new billboards. More recent ordinance amendments allow for replacement of billboards, but that generally happens when there is a change of billboard ownership. If a billboard is damaged and the cost of fixing the billboard is more than 60% of the cost of reconstructing the billboard, it must be removed. Additionally, an ordinance passed in 2005 allowed for the relocation of billboards to new places, provided the new locations were more than 500 ft from a residential structure on a residentially zoned property, more than 500 ft from a historic property or district, and not on a Scenic Roadway.

Los Angeles regulatory environment

The Los Angeles City Council passed a law in 2002 providing for a billboard inventory, inspection, and fee program. As of 2008, there is a moratorium prohibiting any new off-site billboards within the city of Los Angeles. On-site billboards advertising for a specific business are permitted but must adhere to the city codes and requirements. Off-site outdoor advertising is prohibited in the public right-of-way of and on publicly owned land within 500 ft of the center line of a Scenic Highway. A standard condition for discretionary land use approvals involving parcels zoned for non-residential use located within 500 ft of a Scenic Highway is that the property complies with the sign requirements of the CR zone. Designated Scenic Highways have the first priority for removal of nonconforming billboards or signs. Such priority extends to properties located along, or within, 500 ft of the center line of, designated Scenic Highways.

Philadelphia regulatory environment

In Philadelphia, billboards are regulated differently than on-premise, or storefront, signs. Philadelphia's outdoor advertising controls prohibit billboards in certain areas, determined either by base zone or by a special "overlay" zone. In general, the city's controls regulate size, height, and illumination of billboards. The code also establishes special protected areas. For the purposes of this study, we were most interested in protections around child-serving institutions. Since 1991, the Philadelphia code has prohibited billboards within 660 ft of any park, playground, recreation center, play lot, public or private pre-school, and elementary, middle, or high schools. These regulations have prevented new outdoor advertising in these areas, but hundreds of billboards that pre-date the ordinance are still standing.

In recent years, the Philadelphia Department of Licenses and Inspections (L&I) has worked to eliminate illegal billboards and enforce fees. In 2005, L&I struck a deal with Clear Channel, which owns a majority of billboards in Philadelphia, to pay for removal of 958 illegal "8-sheet" billboards owned by other companies. In exchange, the city legalized 239 of 1538 billboards in Clear Channel's inventory that have no zoning permits without regard to "protected areas" specified in the zoning code. In addition, the Philadelphia City Council passed Bill 050865 in 2005 prohibiting signs (billboards or store signs) advertising alcohol within 1000 ft of schools, playgrounds, child care centers, recreation centers, and libraries, with $300 fines for violations. This law is being challenged by the billboard industry and has not been enforced to date.

Unique to Philadelphia in this study was the high concentration of on-premise, storefront signs, particularly the "one-sheet" tobacco ads so common on neighborhood markets. This kind of on-premise signage is regulated separately from outdoor adverting according to the base zone or by overlay zone, which dictates the amount of signage permitted on a commercial property. For storefronts, the Philadelphia code does not distinguish between identifying signage (e.g. "Joe's Deli") and incidental signage (signs promoting goods and services that are "incidental" to the business, such as signs for beer, tobacco, and food items sold on site).

Please cite this article as: Hillier, A., et al., Clustering of unhealthy outdoor advertisements around child-serving institutions: A comparison of three cities. Health & Place (2009), doi:10.1016/j.healthplace.2009.02.014

Data collection and analysis

Outdoor advertisements

Digital cameras and GPS devices were used to record the content and location of outdoor ads in each of the cities within a 60-day period between June and September 2005. This 4-month time period represents the "summer" season; so we have no reason to believe that the content of the ads would be significantly different from one city to the next. Outdoor advertisements, particularly billboards, are leased in 30-day increments and frequently leased for multiple 30-day periods (Outdoor Advertising Association of America, 2008). Only commercial grade outdoor advertisements visible from the street or sidewalk—including billboards, bus bench and shelter advertisements, and store window posters at least 8″ × 12″—were included. Advertisements on buses and non-permanent signs that were hand-drawn or painted were not included. In addition to longitude and latitude coordinates, information about the approximate size and height (in stories), setting (free standing, attached to building, bus shelter, attached to pole, etc.), and content was recorded in the field.

Coders at UCLA analyzed the product content of the ads from all three cities based on the photographs using an abstraction form developed by researchers from the collaborating academic institutions and pre-tested with a small sample of ads. Coders used photographs to determine the size of each ad based on ad "sheets." The term "sheet" is commonly used within the outdoor advertising industry and is approximately 9 ft^2. Ads in store windows might be 1 or 2 sheets while billboards generally consist of 8, 30, 60, or 90 sheets. Ads for sugary beverages, fast food, alcohol, and tobacco were defined as "unhealthy." Ad locations were mapped based on the longitude and latitude coordinates using the ArcView 9.1 software. In many cases, there were multiple ads at a single location. Ads with photographs but no location coordinates were included in descriptive analyses but not the regression models. In Philadelphia, photographs of 69 of the 460 unhealthy advertisements (15%) could not be matched to location coordinates because of data collection errors.

Child-serving institutions

Child-serving institutions were defined as schools (public, private, and charter; elementary, middle school, and high school), day-care centers (public and private), public recreation centers, and public libraries. Data on schools and day-care centers were purchased from InfoUSA for all three cities. These were mapped using the longitude and latitude coordinates provided by InfoUSA and represented as points. Names and addresses of recreation centers and libraries were obtained from municipal recreation department websites and geocoded using a TIGER street centerline file in ArcView GIS 9.1. These were combined into a single map layer.

Neighborhood characteristics

Block group-level data from the 2000 US Census SF-3 file were used to characterize the areas in which the child-serving institutions were located. Block groups were chosen because they are the smallest geographic units for which the census provides income data. They are also much smaller than zip code areas, allowing us to distinguish different parts of the areas that we surveyed. Data on median household income, percent Hispanic, percent non-Hispanic black, population density (people per square mile), child density (children under 18 per square mile), and percent vacant properties were downloaded from American FactFinder and mapped using ESRI TIGER shapefiles. By using block group-level income data rather than zip code, we also minimized problems with different income selection criteria used in Austin to choose zip code areas.

Zoning and land use data

Unlike the demographic data available through the US Census, there is no standardized data set for land use for the entire country. Zoning and land use data were collected only for Los Angeles and Philadelphia because appropriate map layers for Austin were not readily available. Our preliminary results showed that there was no clustering of unhealthy ads around child-serving institutions in Austin; so land use data were not needed to determine if land use explained ad clustering. Data on zoning and land use were provided by municipal agencies. For Los Angeles, the 2007 General Plan was used for land use and the 2007 zoning layer from the Los Angeles Department of City Planning was used for zoning. Both layers excluded Downey (90240) and were incomplete for zip code area 90056. For Philadelphia, only a zoning layer was available. Land use was determined using block group data on the percent of properties designated as commercial by the Board of Revision of Taxes in 2007 and was obtained from the Philadelphia Neighborhood Information System (NIS).

The location of alcohol outlets was obtained from the respective state alcohol control boards and geocoded using a TIGER street centerline file in ArcView. Alcohol outlets that sell alcohol to be consumed only off-premises were distinguished as off-premised outlets. Map layers of bus stops were obtained from metropolitan transit authorities. For Los Angeles, numbers of boardings and alightings were combined to determine the total amount of daily activity. For Philadelphia, the total number of bus lines that use each stop was used as a proxy for daily activity because information on boardings and alightings was not available. The location of retail food outlets in Los Angeles was determined from the Environmental Health Department within the Department of Public Health. The location of supermarkets, grocery stores, and chain convenience stores in Philadelphia was purchased from TradeDimensions.

Major streets were defined as those coded by the US Census Bureau (cfcc) as A1, A2, or A3 in the TIGER street centerline file for each city, which includes federal interstates and state highways.

Data analysis

The numbers of unhealthy advertisements and ad sheets within 1000, 1500, and 2000 ft of child-serving institutions were determined using buffer, clip, and spatial join functions in ArcView. Previous studies and advertising ordinances employ a range of distances when identifying areas "near" schools. Pasch et al. (2007) counted ads within 1500 ft of schools; Philadelphia prohibits alcohol ads within 1000 ft and all billboards within 660 ft of child-serving institutions; the Outdoor Advertising Association of America (OAAA) pledged to voluntarily eliminate tobacco and alcohol ads within 500 ft of schools, playgrounds, and churches (Scott et al., 2008). We used several different distances to allow results to vary by city since the street layout and typical block length varied in the three cities. One thousand feet corresponds roughly to two blocks in Philadelphia and one or two blocks in Austin and LA. In addition, because there has been no definitive analysis of the geographic scale at which unhealthy ads influence children, our statistical analyses allowed for multiple distances. Corrections were made for the "boundary effects" because some institutions were located less than 2000 ft from the boundary of the zip code area canvassed for ads. The proportion of the area included within the surveyed zip codes was computed and ad and sheet counts were weighted based on this proportion.

The total length (in feet) of major streets within 1000-, 1500-, and 2000-ft areas around all child-serving institutions was determined using the buffer, clip, and spatial join functions in ArcView. The percent of all classified land within the land use (LA) and zoning (LA and Philadelphia) layers classified as commercial was determined for 1000-, 1500-, and 2000-ft areas around all child-serving institutions. The numbers of food stores, alcohol outlets (on- and off-premises), and bus stops weighted by total activity within 1000-, 1500-, and 2000-ft areas around all child-serving institutions were calculated in the same manner. The Euclidean distance between each institution and the closest ad was calculated using the spatial join function in ArcView. Descriptive statistical analysis was performed using SPSS 10.0.

Tests of significant clustering of unhealthy ads and total sheets of unhealthy ads were conducted using Ripley's local K function in a program written for MatLab by Tony E. Smith. Ripley's local K function compares the distribution of events (outdoor ads) to randomly generated point patterns to test the null hypothesis of complete spatial randomness (Bailey et al., 1995). Because the null hypothesis may be unrealistic (for example, outdoor ads would not be expected in parks or rivers), the randomly generated patterns are weighted based on a "backcloth" representing total population by census block. Clustering was tested for scales of 1000, 1500, and 2000 ft.

Regression analysis was conducted first using Ordinary Least Squares (OLS) to determine whether racial/ethnic composition and median household income of the block group predicted the number of ads and ad sheets near child-serving institutions controlling for land use characteristics. An exposure measure based on the density of ads within 6000 ft (with a distance-decay weighting) was used as the dependent variable to avoid zero or near-zero ad counts. The log of the exposure measures was used to generate an approximately normal distribution.

Significant spatial autocorrelation was anticipated because the same ads influenced the exposure measure for multiple child-serving institutions in many cases since the exposure areas overlapped. We tried first to capture this using spatial autoregressive (SAR) and spatial lag (SP-LAG) models incorporating weight matrices based on nearest neighbors and the density of institutions with 6000 ft of each institution. We also calculated the correlation matrix among ad exposures and used this to estimate the covariance matrix in order to calculate a generalized least squares (GLS) model. The exposure measure was transformed using a Cholesky decomposition so that the GLS model could be converted to OLS. For all models, stepwise regression was used in order to allow independent variables to be included at multiple scales (1000, 1500, and 2000 ft) to determine which were most influential and to avoid problems with multi-colinearity.

Results

The total area of the canvassed zip codes for each city varied considerably. In Austin, the nine selected zip codes covered 79.1 square miles, while in Los Angeles they covered 14.3 square miles and 12.3 square miles in Philadelphia. Population densities also varied across the three cities, with 4000 people per square mile in Austin, 6000 in LA, and 14,000 in Philadelphia.

Advertisements by category

Austin had the fewest unhealthy ads (38) and the lowest proportion (12.8%) of unhealthy ads relative to all ads, but it had the greatest number of unhealthy ad sheets (1718) because of the large number of billboards (for a total of 11,281 ad sheets). Los Angeles had 187 unhealthy ads (41.5% of all ads) and 1393 unhealthy sheets, which constituted 31.3% of all ad sheets. Philadelphia had the greatest number of unhealthy ads (460), 72% of which were for unhealthy products. Most of the Philadelphia ads were single sheets rather than billboards; so even though a higher proportion (37.5%) of ads sheets fell in the "unhealthy" category, Philadelphia had fewer total unhealthy ad sheets (1138) than Los Angeles or Austin (see Fig. 1). In Austin, many of the ads not categorized as unhealthy were for real estate, insurance, and banking; in LA, they were for entertainment (television and movies); in Philadelphia, there was a mix of

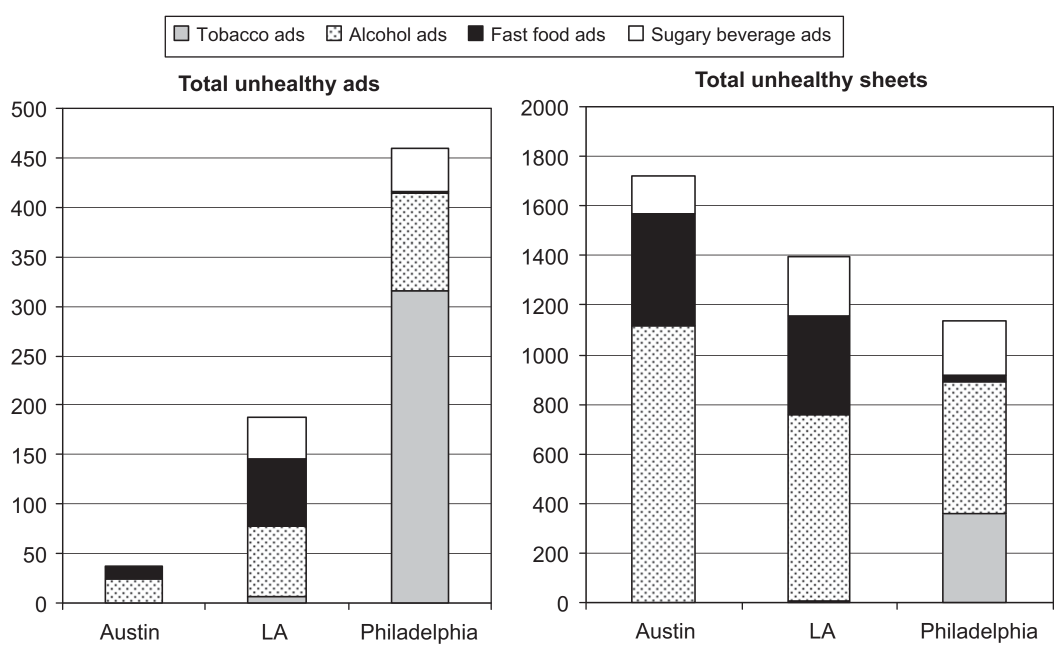

Fig. 1. Unhealthy advertisements by category in three cities.

Please cite this article as: Hillier, A., et al., Clustering of unhealthy outdoor advertisements around child-serving institutions: A comparison of three cities. Health & Place (2009), doi:10.1016/j.healthplace.2009.02.014

Table 1
Ads and ad sheets in relation to child-serving institutions.

	Austin	Los Angeles	Philadelphia
Ads within 1000 ft	5 (3.5%)	47 (42.7%)	95 (66.4%)
Ads within 1500 ft	13 (9.1%)	55 (50%)	115 (80.4%)
Ads within 2000 ft	18 (12.6%)	74 (67.3%)	129 (90.2%)
Mean (SD) ads within 1000 ft	0.04 (0.20)	1.93 (3.28)	6.25 (8.25)
Mean (SD) ad sheets within 1000 ft	1.96 (10.40)	12.97 (24.53)	17.47 (26.57)
Mean (SD) ads within 1500 ft	0.13 (0.46)	4.16 (6.23)	13.38 (14.39)
Mean (SD) ad sheets within 1500 ft	2.45 (11.77)	25.59 (44.41)	34.81 (39.69)
Mean (SD) ads within 2000 ft	0.27 (0.80)	6.11 (8.77)	53.29 (52.79)
Mean (SD) ad sheets within 2000 ft	12.85 (41.71)	37.58 (55.11)	137.05 (155.93)
Mean (SD) distance from unhealthy ads (ft)	2402.8 (1924.7)	967.3 (573.5)	743.6 (767.5)
Median distance from unhealthy ads (ft)	1649.3	983.1	589.3

entertainment (television, movies, and radio), lottery tickets, and banking.

In Austin, the most popular category of unhealthy ads was alcohol; in Los Angeles it was alcohol and fast food. In Philadelphia, the greatest number of unhealthy ads was for tobacco, consisting largely of single sheet tobacco ads outside convenience stores. For ad sheets in Philadelphia, alcohol was the largest category.

Concentration of ads around child-serving institutions

In Austin, the ratio of child-serving institutions to unhealthy ads within the entire study area was approximately 4:1, meaning that for every four schools, day-care centers, recreation centers, and libraries in the study area, there was one unhealthy ad. For ad sheets in Austin, the ratio was approximately 1:12, because so many of Austin's ads are large billboards. In Los Angeles, the ratio of institutions to ads was approximately 2:1 and ad sheet ratio was 1:13. In Philadelphia, the ratio of institutions to ads was about 1:3 and the ad sheet ratio was 1:7.

The differences between cities were even greater when we looked at the area immediately surrounding the child-serving institutions, as shown in Table 1. In Austin, only 3.5% of institutions had ads within 1000 ft compared with 42.7% of institutions in Los Angeles and 66.4% of institutions in Philadelphia. Two thirds of institutions in LA and nearly all institutions in the Philadelphia study area (90.2%) had unhealthy ads within 2000 ft, but only 12.6% of institutions in Austin did. Philadelphia, also had the highest total of unhealthy ads and ad sheets surrounding child-serving institutions, with 53 ads and137 ad sheets within 2000 ft, followed by Los Angeles (6 ads and 38 ad sheets) and then Austin (less than 1 ad and 13 ad sheets). The average distance from child-serving institutions to unhealthy ads was the lowest in Philadelphia (744 ft $\pm$SD 1650 ft), followed by Los Angeles (967 ft $\pm$983 ft) and Austin (2403 ft $\pm$1649 ft).

None of these descriptive statistics indicate that there is any clustering of unhealthy ads around child-serving institutions in Austin; so further clustering analyses were conducted only for Los Angeles and Philadelphia. Local K function tests on total ads and ad sheets indicated statistically significant clustering of unhealthy ads around child-serving institutions in Los Angeles and Philadelphia at scales of 1000, 1500, and 2000 ft (see Table 2). Significant clustering of ads was the least prevalent at 1000 ft (13.6% and 18.4% of institutions in Los Angeles and Philadelphia, respectively) and the most prevalent at 2000 ft (24.5% and 27.9%). Significant clustering ad sheets followed similar patterns, with a low of 14.5% of institutions in Los Angeles and 14.0% in Philadelphia at 500 ft and 20.0% and 20.1%, respectively, at 2000 ft.

Table 2
Institutions with significant clustering of ads based on local K function.

	1000 ft	1500 ft	2000 ft
Los Angeles	15 (13.6%)	19 (17.3%)	27 (24.5%)
Philadelphia	25 (18.4%)	29 (21.3%)	38 (27.9%)

Table 3
Institutions with significant clustering of ad sheets based on local K function.

	1000 ft	1500 ft	2000 ft
Los Angeles	22 (20.0%)	16 (14.5%)	22 (20.0%)
Philadelphia	31 (22.8%)	27 (19.9%)	30 (20.1%)

Table 4
Clustering of ads around child-serving institutions at 1000 ft by income/race.[a]

	Los Angeles		Philadelphia	
	No clustering	Clustering	No clustering	Clustering
High-income black	4 (100%)	0 (0%)	17 (85%)	3 (15%)
High-income Hispanic	1 (50%)	1 (50%)	1 (100%)	0 (0%)
High-income mixed	3 (60%)	2 (40%)	NA	NA
High-income white	4 (100%)	0 (0%)	29 (83%)	6 (17%)
Low-income black	17 (77.3%)	5 (22.7%)	28 (73%)	10 (27%)
Low-income Hispanic	36 (76.6%)	11 (23.4%)	17 (89%)	2 (11%)
Low-income mixed	7 (100%)	0 (0%)	1 (25%)	3 (75%)
Low-income white	1 (100%)	0 (0)	18 (95%)	1 (5%)
Total	73 (79.3%)	19 (20.7%)	111 (82%)	25 (18%)

[a] Race/income designations based on 2000 US Census block group data.

The racial/ethnic and income composition of the block group areas in which institutions with clustering were located did vary somewhat from areas in which institutions without clustering were located. In Los Angeles, all of the institutions with clustering of unhealthy ads and ad sheets at 1000 ft were located in predominantly non-white block groups, although there were too few institutions located in predominantly white block groups to compute a chi-square statistic (see Tables 3 and 4). In Philadelphia, 30.5% of institutions located in predominantly non-white block groups had significant clustering at 1000 ft while only 11.1% of institutions in predominantly white block groups did (χ 6.9; p-value$<$0.01). The results presented in Tables 3 and 4 are based on a distance of 1000 ft to allow for the most conservative analysis of clustering.

For the regression analysis for Los Angeles, an OLS model with a reduced data set ($N = 76$ institutions) was tested to determine

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Table 5
Clustering of ad sheets by income/race category in Los Angeles and Philadelphia.

	Los Angeles		Philadelphia	
	No clustering	Clustering	No clustering	Clustering
High-income black	4 (100%)	0 (0%)	17 (85%)	3 (15%)
High-income Hispanic	2 (100%)	0 (0%)	1 (100%)	0 (0%)
High-income mixed	3 (60%)	2 (40%)	NA	NA
High-income white	4 (100%)	0 (0%)	29 (82.9%)	6 (17.1%)
Low-income black	16 (72.7%)	2 (27.3%)	24 (63.2%)	14 (36.8%)
Low-income Hispanic	39 (83.0%)	8 (17.0%)	14 (73.7%)	5 (26.3%)
Low-income mixed	7 (100%)	0 (0%)	1 (25%)	3 (75%)
Low-income white	1 (100%)	0 (0%)	19 (100%)	0 (0%)
Total	76 (82.6%)	16 (17.4%)	105 (77.2%)	31 (22.8%)

whether the land use and zoning classifications were significant, because the land use and zoning data used did not cover zip code 90240 or all of 90056. Because neither of the variables were significant, all subsequent models for Los Angeles were run with the complete ($N = 89$ institutions) data set without the land use and zoning variables.

OLS results indicated a strong model fit, with an adjusted R^2 of 0.63 (see Table 5). Institutions in block groups with high percentages of white residents were significantly less likely to have clustering of unhealthy ads. The presence of major streets (1500 ft), alcohol outlets (1500 ft), off-premises alcohol outlets (1500 ft), food stores (2000 ft) and bus stops (2000 ft) were all significant positive predictors of ad clustering. In the more conservative GLS model, the percent of white residents remained a significant inverse predictor of ad clustering. Higher population densities (block group), percent vacant properties (block group), alcohol outlets (1500 ft), and bus stops (2000 ft) were all significant positive predictors of ad clustering. The adjusted R^2 for the GLS model dropped to 0.27 and the AIC increased slightly from 338.0 to 339.4, indicating a slight decrease in the goodness of fit but still a fairly strong model (see Table 5). Like adjusted R^2, AIC (Akaike's Information Criterion) allows for the comparison of models with different numbers of parameters, but it offers a more appropriate measure of goodness of fit for GLS models.

Regression results for exposure to ad sheets were similar, with a slight increase in the GLS model fit. The percent of white residents was significant (0.03) in the OLS model and marginally significant (0.059) in the GLS model as a negative predictor of clustering. The presence of major streets (1000 and 2000 ft), alcohol outlets (2000 ft), off-premises alcohol outlets (1500 ft), and bus stops (1500 and 2000 ft) were all significant positive predictors of clustering at the $p<0.05$ level (see Table 6).

For Philadelphia, the OLS results also indicated a good fit (adjusted R^2 0.51), and both income and racial/ethnic composition were statistically significant in the untransformed OLS models of ad exposure. As expected, higher income areas had fewer ads while areas with a higher proportion of African-American/black residents had more ads. Several of the land use variables were also significant. The presence of major streets (2000 ft), food stores (2000 ft), and off-premises alcohol outlets (2000 ft) were all significant positive predictors of clustering while the percent of commercial properties was a significant negative predictor. In the GLS model, income was no longer significant, but percent African American/black remained significant along with the number of major streets (1500 ft) and off-premises alcohol outlets (1000 ft). The adjusted R^2 for the GLS model was much smaller (0.09), indicating that the OLS model overstated the goodness of fit; but transposing the variables with the Cholesky decomposition can

Table 6
Regression results for ad exposure in Los Angeles.

Variable	Coefficient	*t*-Statistic	*p*-Value
Constant	0.144178	0.843914	0.401143
Population density	0.000005	2.766538	0.006982
%NH white	−1.635068	−2.156892	0.033906
%Vacant properties	−2.354361	−2.132887	0.035888
Alcohol outlets (1500 ft)	0.106477	4.621256	0.000014
Bus stops (2000 ft)	0.000064	3.761258	0.000314
R^2	0.3150		
Adjusted R^2	0.2737		
AIC	338.0482		
AIC corrected	339.4309		

Table 7
Regression results for ad sheet exposure in Los Angeles.

Variable	Coefficient	*t*-Statistic	*p*-Value
Constant	0.478609	3.128444	0.002452
Population density	0.000006	2.892356	0.004923
%NH white	−1.140252	−1.908391	0.059928
Major streets (1000 ft)	0.000168	2.845121	0.005636
Major streets (2000 ft)	0.000090	2.102822	0.038625
Alcohol outlets (2000 ft)	0.065269	4.551903	0.000019
Off-premise alcohol outlets (1500 ft)	0.106071	3.450132	0.000897
Bus stops (1500 ft)	0.000154	4.703607	0.000011
Bus stops (2000 ft)	0.000039	2.611826	0.01075
R^2	0.4914		
Adjusted R^2	0.4406		
AIC	312.4827		
AIC corrected	315.3032		

Table 8
Regression results for ad exposure in Philadelphia.

Variable	Coefficient	*t*-Statistic	*p*-Value
Constant	0.494244	4.790247	0.000004
%NH black	0.00133	2.257423	0.025624
Major streets (1500 ft)	0.000016	2.175981	0.031337
Off-premise alcohol outlets (1000 ft)	0.016665	3.326469	0.001139
R^2	0.1075		
Adjusted R^2	0.0873		
AIC	440.3		
AIC corrected	440.8		

make the adjusted R^2 more difficult to interpret. The AIC increased from 319.3 to 440.8, again indicating that the OLS model had overstated the goodness of fit (see Table 7).

Results for ad sheet exposure were similar to the results for ads. Again, median income was a significant negative predictor of clustering in the OLS model but not the GLS model. The percent black/African American was a significant positive predictor in both models as were major streets (1500 ft) and off-premises alcohol outlets (1000 ft). Again, the adjusted R^2 decreased dramatically (from 0.52 to 0.09) and the AIC increased (from 389.4 to 492.2; see Tables 8 and 9).

Discussion and conclusions

We set out to answer four research questions: (1) Do outdoor advertisements for unhealthy products cluster around institutions

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Table 9
GLS regression results for ad sheet exposure in Philadelphia.

Variable	Coefficient	*t*-Statistic	*p*-Value
Constant	0.606187	4.863238	0.000003
%NH black	0.001512	2.123403	0.035586
Major streets (1500 ft)	0.000015	1.762294	0.080334
Off-premise alcohol outlets (1000 ft)	0.017808	2.942424	0.003848
R^2	0.0889		
Adjusted R^2	0.0682		
AIC	491.8		
AIC corrected	492.2		

that serve children in Austin, Los Angeles, and Philadelphia? (2) Are outdoor advertisements for unhealthy products more likely to be clustered around child-serving institutions in racial/ethnic minority and low-income areas? (3) Do land use patterns account for differences in clustering by neighborhood racial/ethnic and income composition? And (4) Do spatial patterns in unhealthy outdoor ads vary by city?

We found that results did vary by city. Ads for unhealthy products did not cluster around child-serving institutions in Austin, but they did cluster around such institutions in Los Angeles and Philadelphia. We found that the presence of blacks and Latinos helped predict that clustering, but median household income did not. Many of the land use variables—major streets, food outlets, alcohol outlets, and bus stops—also helped to explain clustering, but they did not explain away the influence of racial/ethnic composition. In identifying a concentration of ads near schools and in areas with a high proportion of racial/ethnic minority residents, our results are similar to those from other recent studies (Pasch et al., 2008; Scott et al., 2008).

Our results raise a number of questions. First, why were unhealthy ads clustered around child-serving institutions, especially in minority neighborhoods, in LA and Philadelphia? Do advertisers or outdoor advertising companies specifically target children who use these institutions? While possible, a more likely explanation is that children, particularly children of color, in Los Angeles and Philadelphia are served by institutions that are located in areas of many other urban activities, such as shopping, making them vulnerable to exposure to unhealthy ads. Also, zoning ordinances and other controls may be less likely to be enforced in communities of color. This is something that future studies might investigate. Ultimately, the intent of advertisers may not matter if the health effect is the same.

What does it mean that unhealthy ads significantly cluster around child-serving institutions, especially in areas with racial/ethnic minorities? The descriptive statistics offer more easily interpretable results than the regression analyses. In Philadelphia, the extreme case, two thirds of all institutions had an unhealthy ad within 1000 ft and the typical institution had six unhealthy ads within 1000 ft. This is a distance of less than two city blocks, and in many of the public school feeder areas, the majority of public elementary school students live within 2000 ft (less than a half mile) of their school. In Los Angeles, where blocks tend to be longer, 50% of institutions had unhealthy ads within 1500 ft and typical institutions had more than four unhealthy ads within 1500 ft. In other words, most children in Los Angeles and Philadelphia—especially in areas with racial/ethnic minorities—could be exposed to multiple unhealthy outdoor ads on a daily basis just by walking to school.

Finally, why are the patterns in outdoor advertising so different for the three cities? Land use and outdoor advertising regulations offer a partial explanation. Racial/ethnic composition played a significant role in LA and Philadelphia, but the different racial/ethnic make-up of these cities helped explain why percent non-Hispanic white was significant in LA while percent African American/black was significant in Philadelphia. In Los Angeles, Latinos—not blacks—made up the largest "minority" population, comprising 47% while blacks compose only 11% of the population. In Philadelphia, blacks made up 43% of the population and Latinos only 8.5% (2000 US Census). Austin is considerably different from both Philadelphia and Austin, with a higher percent of white residents (65%) a much lower residential density, and very limited public transportation. In addition, Austin has a very different regional culture that is less permissive of outdoor advertisements, as reflected in the long-term moratorium on billboards. Rosman (1993) hypothesized that court decisions against advertisers for discriminatory advertising can have a "chilling effect" on advertising, in general, which could also help account for the lack of clustering found in Austin (Williams et al., 1995).

Existing land use patterns and regulations do not explain away differences across race and income in outdoor advertising, especially considering that the zip codes in which unhealthy ads are concentrated are part of the same city with the same rules and regulations. Corporations often offer the "demand" explanation for these differences—that they are merely responding to the types of products and services preferred by ethnic minority/low-income groups. Demand created by advertising is, in fact, their stock in trade; if it did not work, they would not devote such large proportions of their budgets to it. More likely, this behavior relates to profitability; profit margins are higher on highly processed foods than low-nutrient-density foods like fruits and vegetables. Moreover, foods high in salt, sugar, and fat are more "addictive" in that overconsumption may be more readily induced. Affluent populations with the leisure time and financial resources to resist this "clutter" in their neighborhoods do so.

Land use patterns and regulations do not account for all of the differences in the clustering of unhealthy ads within cities, but they do help explain differences across cities—as seen in Austin. Therefore, land use regulations, including zoning, offer one of the best tools for promoting equity and health (Maantay, 2001). Zoning and land use regulations were originally designed in the early 1900s to protect the health and welfare of the public. Land use regulations can take the form of across-the-board moratoriums like those in effect in Austin and Los Angeles, which prohibit new billboards. But Philadelphia's clustering of unhealthy ads has little to do with the lack of such a moratorium and much more do to with regulations relating to signs outside of stores that receive far less attention from policy makers. Zoning was originally intended to separate out different land uses, keeping industrial activity away from residential areas. While recent research on "walk-able" communities has highlighted the healthy aspects of mixed land uses, particularly the presence of commercial food establishments near residential areas (Sallis and Glanz, 2006; Frank et al., 2006), unhealthy outdoor ads may simply not belong in residential areas or areas immediately around child-serving institutions.

As with all observational field studies, there are many limitations that need to be acknowledged. We surveyed a fairly small sample of outdoor advertisements in areas that were selected based on their demographic variability, not at random, which limits the generalizability of our findings. Furthermore, we used slightly different income criteria for selecting zip code areas across the three cities and used slightly different land use measures, which may limit the comparability of our results. The loss of location data for 15% of the ads in Philadelphia may also have impacted the results—either overstating the influence of race or understating the influence of income—but analysis of the missing data suggests that this is unlikely.[6] By measuring exposure using a distance-decay density function, we assumed that physical proximity means exposure, without distinguishing the influence that unhealthy ads might have on students depending on their route and means of transportation to school or personal characteristics. Our study is cross-sectional, capturing outdoor advertising content at only one point in time even though outdoor ads are changing constantly. Finally, this study did not link exposure to ads to subsequent health outcomes. These are all limitations that future research should try to overcome through larger random samples and longitudinal study designs that track children's exposure, health behaviors relating to eating, physical activity, drinking, and smoking, and health outcomes across different age groups. Some recent efforts are consistent with this recommendation (Pasch et al., 2007).

By categorizing four distinct kinds of ads as "unhealthy," this research does not distinguish how exposure might impact health depending on the content of the ad. Similarly, looking at all child-serving institutions together, this research fails to consider how children use these different institutions—day-care centers, schools, libraries, and recreation centers—differently over their life course. But our results provide evidence that number and content of ads near places where children spend time warrant further attention, which could include studies that focus on just one type of unhealthy ad or one type of child-serving institution.

The strengths of this study are also noteworthy. First, it compared outdoor advertising in three cities, allowing us to identify differences—such as the presence of clustering—and similarities—such as the influence of racial/ethnic composition. By surveying ads for alcoholic beverages, tobacco products, sugary beverage, and fast food around all types of child-serving institutions, we offered a broad conceptualization of children's health. While studies that focus on only one category of unhealthy ads—such as alcohol—will have more success identifying the specific causal pathway to negative health outcomes, our approach looks more holistically at children's well-being and patterns within the outdoor advertising industry. By deliberately not surveying billboards along highways, parts of cities known to be saturated with outdoor ads were excluded, but this approach helped focus attention on the strong presence of outdoor advertising in residential areas.

If our findings are replicated for other locations, one inference is that, to bring about change, researchers and advocates need to frame outdoor advertising as an issue of environmental justice (Taylor et al., 2006; Dannenberg et al., 2003). While free-speech legal protections may constrain efforts to regulate outdoor advertising content (Kline et al., 2006), zoning regulations can be used to protect children from unhealthy ads near their schools and other institutions that serve them, so long as those regulations are enforced. Sloane et al. (2003) show how community-based participatory research provides a model for community members and researchers to collaborate on studying and mitigating the exposure of outdoor advertising on children and communities of color. When municipal agencies fail to enforce regulations, like Philadelphia's prohibition against alcohol ads within 660 ft of child-serving institutions or the OAAA's voluntary ban on alcohol and tobacco ads within 500 ft of schools, playgrounds, and churches, community members and researchers armed with GPS, GIS, and digital cameras may be critical for enforcement. The combined efforts of community advocates, researchers, and public officials may make it possible to create zones free of unhealthy ads around the public places where impressionable children spend much of their time.

[6] Almost all of these ads were located in the three low-income zip code areas, and most were for tobacco products. One of the zip codes was predominantly African-American/black (19132), one Latino (19132), and one was chosen as predominantly white (19148) but included a more racially mixed population than the other two areas. The inclusion of additional unhealthy ads in 19132 and 19133 would have likely reinforced results linking racial/ethnic minority population to the clustering of unhealthy ads. It is clear that most of the photos without location data for 19148 were for ads posted on stores. A map of the zip code shows that the majority of stores are in the non-white areas; so inclusion of these missing ads might have also reinforced the link between racial/ethnic minority areas and clustering of unhealthy ads. Furthermore, because almost all of the missing ads were in low-income areas, the relationship between low-income areas and ad clustering might have been significant.

Acknowledgements

This research was supported by grants from the California Department of Health Services' California Nutrition Network for Healthy, Active Families, University of Texas Advertising Department, and Penn–Cheyney EXPORT Center for Inner City Health, NIH MD P60 000209, from the National Center for Minority Health and Health Disparities. We gratefully acknowledge the field data collection conducted in Philadelphia by Professor Marilyn Guidry and her students from Cheyney University and in Austin by undergraduate and graduate students at the University of Texas Department of Advertising. Thanks to Nicole Seitz and the staff at the Society Created to Reduce Urban Blight (SCRUB) for assistance understanding Philadelphia's outdoor ad regulations. We also acknowledge Chiquita A. Collins for her insight, comments, and research support during the early stages of the project.

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Please cite this article as: Hillier, A., et al., Clustering of unhealthy outdoor advertisements around child-serving institutions: A comparison of three cities. Health & Place (2009), doi:10.1016/j.healthplace.2009.02.014