



# HHS Public Access

Author manuscript

Prev Med Rep. Author manuscript; available in PMC 2016 January 01.

Published in final edited form as:

Prev Med Rep. 2015 ; 2: 730–736. doi:10.1016/j.pmedr.2015.08.018.

## Examination of community and consumer nutrition, tobacco and physical activity environments at food and tobacco retail stores in three diverse North Carolina communities

Heather D'Angelo, MHS, PhD<sup>a</sup>, Kelly R. Evenson, PhD, MS<sup>b</sup>, Shyanika Rose, MA, PhD<sup>a,c,f</sup>, Sheila Fleischhacker, PhD, JD<sup>d</sup>, Allison E Myers, MPH<sup>a</sup>, and Kurt M Ribisl, PhD<sup>a,c</sup>

<sup>a</sup>Gillings School of Global Public Health, Department of Health Behavior, University of North Carolina, Chapel Hill, NC, USA

<sup>b</sup>Gillings School of Global Public Health, Department of Epidemiology, University of North Carolina, Chapel Hill, NC, USA

<sup>c</sup>Lineberger Comprehensive Cancer Center, University of North Carolina, Chapel Hill, NC, USA

<sup>d</sup>National Institutes of Health Division of Nutrition Research Coordination, Bethesda, MD, USA

<sup>f</sup>Schroeder Institute for Tobacco Research and Policy Studies, Legacy, Washington, DC, USA

### Introduction

Living in a neighborhood with few health promoting resources and with more resources that could undermine healthy behaviors may amplify health disparities observed among racial minority and low-income populations.(Centers for Disease Control and Prevention, 2005) When describing how neighborhood nutrition environments affect dietary behavior, Glanz (Glanz et al., 2005) et al. distinguished between the *community environment* (i.e., the number, type and location of food outlets) and the *consumer environment* (i.e., the

Corresponding Author: Heather D'Angelo, Department of Health Behavior, UNC Gillings School of Global Public Health, CB 7440, Chapel Hill, NC 27599-7440. hdangelo@email.unc.edu, telephone: (919) 636-9759; cell: (413) 214-2687, fax: (919) 966-2921.

#### Financial disclosure

**Ms. Myers** is the Executive Director and **Dr. Ribisl** is the Chief Science Officer of Counter Tools (<http://countertools.org>), a nonprofit that distributes store mapping and store audit tools from which they receive compensation. **Dr. Ribisl and Ms. Myers** receive royalties from a store audit and mapping system owned by the University of North Carolina at Chapel Hill, but the tools and audit mapping system were not used in this study.

**Conflict of interest statement:** **Dr. D'Angelo** and **Ms. Meyers** have no competing interests. **Dr. Rose** is currently employed at the Schroeder Institute at Legacy. **Dr. Ribisl** has received past funding from the NIH, Centers for Disease Control and Prevention (CDC), Robert Wood Johnson Foundation (RWJF), the United States Department of Justice, the NC Health and Wellness Trust Fund Commission, and internal funds at UNC. He has consulted for the Food and Drug Administration (FDA) Center for Tobacco Products and is a member of the Tobacco Products Scientific Advisory Committee—the views expressed in this paper are his and not those of the FDA. **Dr. Evenson** has received past funding from the NIH, CDC, RWJF, Gatorade, the American Heart Association, and internal funds at UNC. **Dr. Fleischhacker** has been supported on grants from the NIH, RWJF, US Department of Agriculture, NC Health and Wellness Trust, and Kate B. Reynolds Charitable Trusts. She is currently employed by the NIH. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or any other entity mentioned in this disclosure statement.

**Publisher's Disclaimer:** This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

availability, price, promotion, and placement of healthy foods within food outlets). Similar distinctions can be applied to tobacco and physical activity environments. In separate lines of research, community environment measures, such as the availability of supermarkets, convenience stores, parks, and playgrounds have been associated with health risk factors such as obesity (Lovasi et al., 2009), smoking (Henriksen et al., 2008) and physical activity (Gordon-Larsen et al., 2006). At the consumer level, healthy food availability within stores (Franco et al., 2009), tobacco marketing at the point-of-sale (Paynter and Edwards, 2009), and park resources (e.g., playgrounds) (Kaczynski et al., 2008) have been associated with diet, smoking, and physical activity, respectively.

Examining community and consumer level access to resources provides a broader understanding of contextual factors that may play a role in multiple health behaviors. But few studies have assessed associations between nutrition, tobacco, and physical activity environments, even though zoning, licensing, and land use policies could impact all three environments at the community level.(Ashe et al., 2003) Further, intervening at retail stores may provide an opportunity to address healthy food availability and tobacco marketing at the point-of-sale, and make changes to improve sidewalks, lighting or other exterior store environments to increase foot traffic or encourage physical activity through walking or bicycling to the store.( ChangeLab Solutions, 2013a, 2013b) Research examining all three environments is particularly timely given current interest in addressing multiple health behaviors. (Centers for Disease Control and Prevention, 2013)

The objective of this study was to examine associations between consumer and community nutrition, tobacco, and physical activity environments within and surrounding stores that sell food and tobacco products. The following research questions were addressed:

1. At the consumer level, do stores with few healthy foods also have high amounts of tobacco marketing and poor environments for physical activity?
2. At the community level, do store neighborhoods with low supermarket access, also have high tobacco outlet density and few community physical activity resources?
3. Are consumer and community environments related? For example, do stores located in neighborhoods with high tobacco outlet density also have fewer healthy foods available?

A secondary objective was to examine community and consumer correlates of healthy food availability within stores, controlling for store and neighborhood characteristics. Healthy food availability was chosen to examine one aspect of the consumer environment that is increasingly the target of nutrition interventions, (Gittelsohn et al., 2014; Gittelsohn et al., 2012) but that may also be associated with the tobacco and physical activity environments within and around stores.

## Methods

### Sample and Study Area

The University of North Carolina at Chapel Hill Institutional Review Board reviewed the study and deemed it exempt from human subjects research. Data on the community and

consumer nutrition, tobacco, and physical activity environments was collected in and around stores that sold food and tobacco products in three geographically diverse North Carolina counties (Buncombe, Durham, and New Hanover). The sample of stores was selected from the population of tobacco retail outlets within the study area, described elsewhere (Rose et al., 2013, D'Angelo et al., 2014) and summarized in Figure 1. Store location, store type and tobacco product availability were verified in the field. (D'Angelo et al., 2014)

Only stores that also sold food were included in analyses, leaving 303 stores in 123 census tracts. The final sample included stores from the following North American Industry Classification System (NAICS) codes using data from 2011: supermarkets and other grocery (except convenience) stores (445110), convenience stores (445120), gasoline stations with convenience stores (447110), warehouse clubs and supercenters (452910), and pharmacies and drug stores (446110).

### Store Observation Protocol

The store observation had four instruments: (1) interior tobacco, (2) exterior tobacco, (3) nutrition environment, and (4) physical activity environment. Each instrument was transferred onto an Apple® iPod touch® using Pendragon™ data collection software. Auditors worked in teams of two. One auditor completed the physical activity audit for the street segment while the other drove. In small stores such as convenience stores, one auditor completed the interior tobacco and nutrition audit while the second completed the exterior tobacco audit. In larger stores (e.g., supermarkets), one auditor completed the nutrition audit and the second completed both tobacco audits. In small stores, auditors typically asked permission to conduct the interior audits and, if questioned by a retailer, provided a project letter. Auditors recorded completion status, whether a store was out of business, not located, or the audit was declined by an employee.

### Measures

Table 1 provides details on all study measures. The consumer environment measures were derived from store audits while the community environment measures were derived from linking aggregated data at the census tract level to each store based on its location. Higher scores for the consumer nutrition and tobacco environment measures indicated greater healthy food availability and more tobacco marketing materials displayed, respectively. For the consumer physical activity environment, higher walk/bike and physical incivility scores indicated a more favorable environment for physical activity (physical incivility score reverse coded).

The community nutrition environment was a dichotomous variable indicating whether or not the store was located in a low supermarket access census tract. (Economic Research Service, 2011) Community measures for tobacco and physical activity counted the number of tobacco selling outlets and parks and physical activity resources (e.g., public swimming pools and private dance studios) per 1000 people within a census tract, respectively. ArcMap 10.1 was used to join tobacco outlets, parks and physical activity resources to census tracts.

## Covariates

Stores were categorized as chain supermarkets/warehouse clubs, non-chain supermarkets, convenience stores, gasoline stations with convenience stores (gas/convenience), or pharmacies and drug stores. Neighborhood income and racial/ethnic composition were measured using the 2006–2011 American Community Survey five-year estimates. Income was measured using median household income. Racial/ethnic composition was defined using percent non-Hispanic Black and percent Hispanic residents. Population density was calculated as the number of people per census tract in thousands, based on data from the 2010 US Census. All continuous variables were centered at the grand mean.

## Statistical Analysis

Descriptive statistics were calculated for all measures, overall and by county. Partial Pearson correlation coefficients were calculated to examine associations among and between consumer and community tobacco, nutrition, and physical activity measures, controlling for county. Correlations were interpreted using the following ratings: 0, poor, 0–0.2 slight, 0.21–0.4 fair, 0.41–0.6 moderate, 0.61–0.8 substantial, and 0.81–<1.0 almost perfect agreement. (Landis and Koch, 1977)

For the secondary aim, a regression model was used to examine associations of consumer and community environment measures with the dependent variable, healthy food availability at the store level. Variables that had partial Pearson correlation coefficients significantly associated with healthy food availability at the  $p < 0.25$  level were retained in the model. The model also controlled for store type, neighborhood demographics, and county. An intraclass correlation coefficient (ICC) was calculated using a null model with healthy food availability as the level one dependent variable and census tracts at level two to determine whether a multilevel or multiple linear regression model was appropriate. The assumptions for the linear regression model were checked and found to be adequate. After stratifying models by county, similar results were found therefore the final model retained county as a covariate.

## Results

The majority of stores were gas/convenience, followed by convenience and chain supermarkets, pharmacies, and non-chain supermarkets (Table 2). The average number of tobacco marketing materials per store were 29.4 interior (range 0–93) and 4.7 exterior (range 0–44). Mean healthy food availability score was 11.0 (range 1–29), walk/bike score was 2.3 (range 0.67–5.67) and physical incivility score was 1.8 (range 0.67–5.1). Buncombe County had significantly more interior tobacco marketing materials compared to New Hanover and Durham Counties ( $p < .0001$ ), and Durham County had a significantly higher walk/bike score ( $p < .0001$ ), but a significantly lower physical incivility score ( $p = 0.002$ ) compared to the other two counties. Mean tobacco outlet density similar across the study area, and 51.7% of tracts were designated as having low supermarket access. Tracts had an average of 0.7 (SD 1.0) physical activity resources per 1000 people.

### Associations among Consumer Environments

Interior and exterior tobacco marketing were positively correlated with fair agreement ( $r=0.25$ , Table 3). Healthy food availability score was negatively correlated with exterior and interior tobacco marketing, and the associations were slight to fair in strength ( $r = -0.13$ ,  $-0.38$ , respectively). Neither walk/bike nor the physical incivility score was associated with any other consumer environment measure.

### Associations among Community Environments

The association of community environment measures ranged from slight to fair (Table 3). Tobacco outlet density was positively correlated with physical activity resource density ( $r = 0.27$ ) indicating that neighborhoods with greater tobacco outlet density also have greater physical activity resources density. Conversely, neighborhoods with few supermarkets had fewer tobacco outlets per 1000 people ( $r = -0.35$ ) and fewer physical activity resources per 1000 people ( $r = -0.20$ ).

### Associations between Community and Consumer Environments

The walk/bike score was positively correlated with fair agreement with both tobacco outlet density ( $r = 0.29$ ) and physical activity resource density ( $r = 0.33$ ) and weakly negatively correlated with low supermarket access ( $r = -0.15$ ) (Table 3). In other words, neighborhoods with more tobacco outlets and more activity resources tended to have a more favorable walking and bicycling environment outside stores, while neighborhoods with few supermarkets had a less favorable environment.

### Correlates of Healthy Food Availability within Stores

A low ICC was calculated ( $ICC = 0.03$ ) indicating that variability in healthy food availability was minimal across census tracts, therefore, multiple linear regression analysis rather than a multilevel model was appropriate. The variance inflation factor (VIF) for each independent variable was less than 4, indicating that multicollinearity was not present. The multiple linear regression model showed that each unit increase in interior tobacco marketing was associated with greater healthy food availability ( $\beta=0.05$ ,  $p=.001$ ), while each unit increase in exterior marketing was associated with lower healthy food availability ( $\beta=-0.08$ ,  $p=0.02$ ), controlling for both store type and community measures (Table 4). That is, stores that had more interior tobacco marketing also had more healthy foods available, while stores with more exterior tobacco marketing had fewer healthy foods available. Chain supermarkets had significantly higher healthy food availability compared with all other store types. Neither tobacco outlet density nor low supermarket access was significantly associated with healthy food availability, and neighborhood income, race/ethnicity and population density were not significant predictors of healthy food availability within stores. Stores in Durham County had significantly higher healthy food availability compared to stores in New Hanover County. Supplementary analyses (not shown) found no difference after adding the number of cash registers to the model as a proxy for store size.

## Discussion

The community nutrition, tobacco, and physical activity environments were significantly, although weakly inter-related in three diverse North Carolina counties. Higher tobacco outlet density was associated with neighborhoods having more physical activity resources and better supermarket access. Areas with more of any type of resource (i.e., more tobacco outlets, supermarkets, and physical activity resources) also had more favorable environments for walking and bicycling, perhaps simply reflecting more urban environments. A study in Germany found that tobacco, alcohol and fast food outlets were all more likely to be located together in lower income neighborhoods, (Schneider and Gruber, 2013) and in South Carolina, fast food outlets clustered around supermarkets. (Lamichhane et al., 2013) Communities have a complex mix of retail and community resources which should be explored further, with particular attention to the types of resources that are located together. Future research could also explore the role of zoning ordinances in determining the types and locations of retail and physical activity resources.

Interestingly, stores with higher amounts of *interior* tobacco marketing had *more* healthy food, even after controlling for store type (and in supplementary analyses after including the number of cash registers), the community nutrition and tobacco environment, and neighborhood demographics. This suggests that even chain supermarkets, typically regarded as health promoting resources compared to smaller food stores, may expose customers to tobacco marketing inside. On the other hand, stores with higher amounts of *exterior* tobacco marketing had *lower* healthy food availability. More research is needed to determine how to effectively measure community and consumer retail environments. Our findings suggest that measuring supermarket access alone missed a broader understanding of contextual factors such as the interior tobacco marketing to which customers are exposed.

The findings of this study have implications for policy and practice. As one example, the City of Minneapolis in Minnesota enacted a Staples Food Ordinance that requires retailers seeking licensure to sell a minimum standard of healthy food (*Minneapolis Code of Ordinances*, Title 10, Ch 203). Other jurisdictions have proposed or enacted similar ordinances or certification programs to encourage retail food outlets, particularly smaller stores, to stock healthier foods and beverages.(ChangeLab Solutions, 2013a) Healthy retailer licensing requirements could be expanded to include provisions to eliminate or place a cap on the amount of tobacco marketing allowed outside the store. Given that we found that stores in neighborhoods with more tobacco outlets are also more walkable, limiting exterior tobacco marketing, particularly for stores located near schools, may reduce youth exposure to tobacco marketing. (Luke et al., 2011)

Similarly, maintaining an attractive premise, including improving lighting, removing graffiti, providing adequate trash receptacles and preventing loitering, is a suggested program requirement for stores to receive incentives to participate in a healthy stores program (ChangeLab Solutions, 2013b). Improving the aesthetics of the store exterior environment could also promote walking and active transport. (Saelens and Handy, 2008) Enhancing both the healthy food offerings and improving the store exterior by removing

tobacco marketing and improving the aesthetics may enhance the store's appeal for customers, which might have additional economic and community development benefits.

### Strengths and Limitations

This study assessed multiple dimensions of community and consumer environments, within three geographically diverse counties. This was a cross-sectional study, therefore causation cannot be established; however, the correlation of environmental factors reveals broader ways of conceptualizing the health promoting potential of the retail environment. The consumer tobacco, nutrition, and physical activity environments were assessed directly through audits and tobacco outlet density was validated in the field. In larger stores, two different data collectors completed exterior and interior audits at the same store, which may have added to measurement error. However, all auditors were centrally trained and monitored using the same protocol on conducting both interior and exterior audits, and there were no significant differences in any of the consumer environment measures by either interior or exterior auditor.

Some of the community level data sources used in the study had limitations; for example, tobacco outlet density was assessed using primary data collected during on-site verification, while secondary data sources were used to determine physical activity resources and supermarket access. The land area of each park rather than the count per tract would have been calculated to account for park size in our calculation of activity resource density. The number of tobacco marketing materials does not give information about the size or area that the signs/ads occupy outside or within a store. Store type may account for differences in store size which could be associated with both healthy food availability and tobacco marketing, and was therefore used as a control variable in regression analyses.

Neighborhood demographics and population density have been associated with the availability of healthy foods (Franco et al., 2009), food outlets (Walker, 2010) and tobacco outlets (Rodriguez, 2012). Therefore, race, ethnicity, median household income and population density at the census tract level were included as covariates in the regression model. Although a commonly used proxy for neighborhood, (Diez Roux, 2001) census tracts may not represent true neighborhood boundaries or the environment where residents usually travel. Future studies could improve upon the definition of neighborhood we used. Also, spatial analysis might account more accurately for spatial autocorrelation of stores, although a low ICC indicated that the variance in healthy food availability attributed to census tract membership was minimal.

### Conclusion

Community and consumer nutrition, tobacco, and physical activity environments were interrelated in three counties in North Carolina. Measures that solely assess community environments could miss important characteristics of the consumer environment that may influence the types of products a customer purchases. Public health research and practice might be more effective if future studies and interventions explore intersections at the point-of-sale in efforts to reduce obesity and tobacco use. Thus far, most of the work in obesity prevention and tobacco control at the point of sale has been done in isolation. More research

is needed to explore whether and how healthy corner stores intervention strategies(Gittelsohn et al., 2012) could have a greater impact through coordinated efforts that limit tobacco marketing and increase opportunities to encourage active transport.

## Acknowledgments

This study was funded in part by the National Institutes of Health (NIH)/National Cancer Institute (U01 CA154281), the University of North Carolina at Chapel Hill (UNC) Lineberger Comprehensive Cancer Center University Cancer Research Fund, and the UNC Lineberger Comprehensive Cancer Education Program doctoral training support (R25) to Shyanika Rose. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or any other entity.

## References

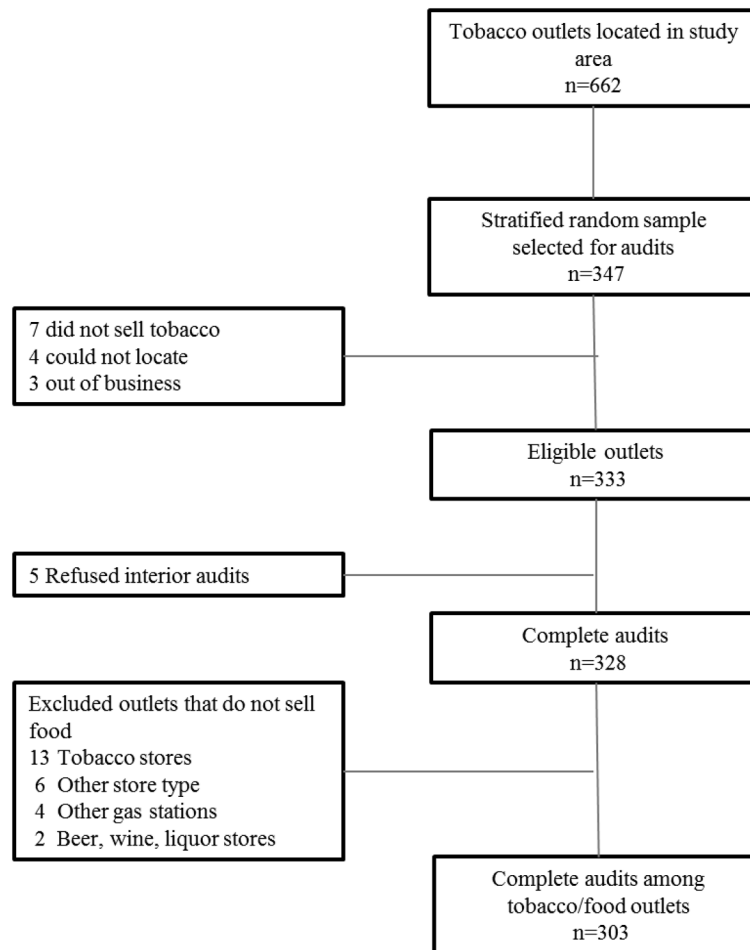
- Ashe M, Jernigan D, Kline R, Galaz R. Land use planning and the control of alcohol, tobacco, firearms, and fast food restaurants. *Am J Public Health*. 2003; 93:1404–1408. [PubMed: 12948952]
- Centers for Disease Control and Prevention. Healthy Communities Program. 2013. <http://www.cdc.gov/nccdphp/dch/programs/healthycommunitiesprogram/>
- ChangeLab Solutions. [accessed March 10, 2014] A Guide to the Model Licensing Ordinance for Healthy Food Retailers. 2013a. [http://changelabsolutions.org/sites/default/files/Licensing\\_for\\_Lettuce\\_FINAL\\_20130212\\_0.pdf](http://changelabsolutions.org/sites/default/files/Licensing_for_Lettuce_FINAL_20130212_0.pdf)
- ChangeLab Solutions. [accessed August 22, 2015] Health on the Shelf. 2013b. <http://changelabsolutions.org/publications/health-on-the-shelf>
- Centers for Disease Control and Prevention. Racial/ethnic and socioeconomic disparities in multiple risk factors for heart disease and stroke--United States, 2003. *MMWR Morbidity and mortality weekly report*. 2005; 54:113. [PubMed: 15703691]
- D'Angelo H, Fleischhacker S, Rose SW, Ribisl KM. Field validation of secondary data sources for enumerating retail tobacco outlets in a state without tobacco outlet licensing. *Health & place*. 2014; 28:38–44. [PubMed: 24742811]
- Diez Roux AV. Investigating neighborhood and area effects on health. *Am J Public Health*. 2001; 91:1783–1789. [PubMed: 11684601]
- Economic Research Service (ERS), U.S. Department of Agriculture. Food Desert Locator. 2011. <http://www.ers.usda.gov/data-products/food-environment-atlas/data-access-and-documentation-downloads.aspx>
- Evenson KR, Sotres-Alvarez D, Herring AH, Messer L, Laraia BA, Rodríguez DA. Assessing urban and rural neighborhood characteristics using audit and GIS data: derivation and reliability of constructs. *Int J Behav Nutr Phys Act*. 2009; 6:44. [PubMed: 19619325]
- Franco M, Diez-Roux AV, Nettleton JA, Lazo M, Brancati F, Caballero B, Glass T, Moore LV. Availability of healthy foods and dietary patterns: the Multi-Ethnic Study of Atherosclerosis. *Am J Clin Nutr*. 2009; 89:897–904. [PubMed: 19144728]
- Gittelsohn J, Laska MN, Karpyn A, Klingler K, Ayala GX. Lessons Learned From Small Store Programs to Increase Healthy Food Access. *Am J Health Behav*. 2014; 38:307–315. [PubMed: 24629559]
- Gittelsohn J, Rowan M, Gadhoke P. Interventions in small food stores to change the food environment, improve diet, and reduce risk of chronic disease. *Prev Chronic Dis*. 2012; 9:E59. [PubMed: 22338599]
- Glanz K, Sallis JF, Saelens BE, Frank LD. Healthy nutrition environments: concepts and measures. *Am J Health Promot*. 2005; 19:330–333. [PubMed: 15895534]
- Glanz K, Sallis JF, Saelens BE, Frank LD. Nutrition Environment Measures Survey in Stores (NEMS-S):: Development and Evaluation. *Am J Prev Med*. 2007; 32:282–289. [PubMed: 17383559]
- Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics*. 2006; 117:417. [PubMed: 16452361]



- Henriksen L, Feighery EC, Schleicher NC, Cowling DW, Kline RS, Fortmann SP. Is adolescent smoking related to the density and proximity of tobacco outlets and retail cigarette advertising near schools? *Prev Med*. 2008; 47:210–214. [PubMed: 18544462]
- Kaczynski AT, Potwarka LR, Saelens BE. Association of park size, distance, and features with physical activity in neighborhood parks. *Am J Public Health*. 2008; 98:1451–1456. [PubMed: 18556600]
- Lamichhane AP, Warren J, Puett R, Porter DE, Bottai M, Mayer-Davis EJ, Liese AD. Spatial patterning of supermarkets and fast food outlets with respect to neighborhood characteristics. *Health & place*. 2013; 23:157–164. [PubMed: 23933445]
- Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977:159–174. [PubMed: 843571]
- Lovasi GS, Hutson MA, Guerra M, Neckerman KM. Built environments and obesity in disadvantaged populations. *Epidemiol Rev*. 2009; 31:7–20. [PubMed: 19589839]
- Luke DA, Ribisl KM, Smith C, Sorg AA. Family Smoking Prevention and Tobacco Control Act: Banning Outdoor Tobacco Advertising Near Schools and Playgrounds. *Am J Prev Med*. 2011; 40(3):295–302. [PubMed: 21335260]
- Paynter J, Edwards R. The impact of tobacco promotion at the point of sale: a systematic review. *Nicotine Tob Res*. 2009; 11:25–35. [PubMed: 19246438]
- Rodriguez D, Carlos HA, Adachi-Mejia AM, Berke EM, Sargent JD. Predictors of tobacco outlet density nationwide: A geographic analysis. *Tobacco Control*. 2012 Sep; 22(5):349–55. Epub 2012 Apr 4. 10.1136/tobaccocontrol-2011-050120 [PubMed: 22491038]
- Rose SW, Myers AE, D'Angelo H, Ribisl KM. Retailer Adherence to Family Smoking Prevention and Tobacco Control Act, North Carolina, 2011. *Prev Chron Dis*. 2013; 10:E47.
- Saelens BE, Handy SL. Built Environment Correlates of Walking: A Review. *Med Sci Sports Exerc*. 2008; 40(7 Suppl):S550–S566.10.1249/MSS.0b013e31817c67a4 [PubMed: 18562973]
- Schneider S, Gruber J. Neighbourhood deprivation and outlet density for tobacco, alcohol and fast food: first hints of obesogenic and addictive environments in Germany. *Public Health Nutr*. 2013; 16:1168–1177. [PubMed: 22781559]
- Walker RE, Keane CR, Burke JG. Disparities and access to healthy food in the United States: A review of food deserts literature, *Health & Place*. 2010; 16(5):876–884. <http://dx.doi.org/10.1016/j.healthplace.2010.04.013>. [PubMed: 20462784]

### Highlights

- Nutrition, tobacco, and physical activity environments were interrelated.
- Stores with more *interior* tobacco marketing had greater healthy food availability.
- Stores with more *exterior* tobacco marketing had lower healthy food availability.
- Walkability was positively correlated with tobacco and activity resource density.
- Future work could combine obesity prevention and tobacco control efforts in stores.



**Figure 1.**  
Identification and random selection of food/tobacco stores in North Carolina, 2011

**Table 1**

Description of consumer and community environment measures

| Construct                                     | Variable   | Definition  | Measurement   |
|---|--|---|---|
| <b>Consumer environment measures</b>          |  |   |   |
| <b>Consumer nutrition environment</b>         | Healthy food availability (HFA) score  | The nutrition audit was a modified version of the previously validated Nutrition Environment Measurement Survey in Stores (NEMS-S) instrument (Glanz et al., 2007) and included the following food and beverages: fruits, vegetables, bread, cereal, milk, beef, hot dogs, frozen dinners, juice, and soda. Availability was measured for all items; price was measured for bread and milk. The healthy food availability score was created using the NEMS-S scoring guidelines for the products included in the audit.   | Continuous, (range 1–29)                                      |
| <b>Consumer tobacco environment</b>           | Interior tobacco marketing materials<br>Exterior tobacco marketing materials   | Marketing materials were counted for all types of tobacco products (i.e. cigarettes, cigars, cigarillos, smokeless tobacco, and e-cigarettes). Interior tobacco marketing materials is the sum of branded tobacco ads, moveable product displays and functional items with tobacco product branding (e.g. clocks).<br>The sum of branded tobacco ads in the parking lot, on the property, and directly attached to the store exterior or on windows facing out.   | Continuous, (range 0–93)<br>Continuous, (range 0–44)          |
| <b>Consumer physical activity environment</b> | Walk/bike score<br>Physical incivility score   | The physical activity audit was conducted on street segments where the store was located. Street segment was defined as the road length between two intersections or between an intersection and a cul-de-sac or dead end road. The audit was modified from the Pregnancy, Infection, and Nutrition (PIN3) Neighborhood Audit Instrument. (Evenson et al., 2009)<br>Walk/bike score was created from the following items in the physical activity audit: sidewalk condition, number of lanes to cross, presence of bicycle lane, shoulder, walking trail, pedestrian friendly signals and street crossings, street lighting, and bicycle parking. A higher walk/bike score indicates an environment more favorable to walking and/or bicycling.<br>Physical incivility score was created from the following items in the physical activity audit: condition of public spaces, presence and condition of parks and playgrounds, and amount of litter. Items were reverse coded such that a higher score indicates a more favorable physical environment for physical activity. | Continuous, (range 0.67–5.67)<br>Continuous, (range 0.67–5.1) |
| <b>Store type</b>                             | Chain supermarkets & warehouse clubs<br>Non-chain supermarkets<br>Convenience store with gas station<br>Convenience store (without gas)<br>Pharmacy/drug store | Supermarkets were combined with warehouse clubs because there were few warehouse clubs and their nutrition and tobacco consumer measures were similar.<br>Supermarkets were further categorized into chain and non-chain by name recognition, and, if necessary, an internet search was conducted to determine chain status. Chain and non-chain supermarkets were distinguished because of the differences in their healthy food availability score. For store type the reference category was chain supermarkets.   |   |
| <b>Community Environment Measures</b>         |  |   |   |

| Construct                                      | Variable                           | Definition  | Measurement  |
|--|------------------------------------|---|--|
| <b>Community nutrition environment</b>         | Low supermarket access             | Low supermarket access was obtained from the United States Department of Agriculture Food Access Research Atlas and is defined as a "census tract where a significant number or share of individuals is far from a supermarket": Defined as living farther than 1 mile from a supermarket for urban areas or 10 miles for rural areas.  | Binary, Low food access vs. not low food access census tract                         |
| <b>Community tobacco environment</b>           | Tobacco outlet density             | Calculated based on the location of tobacco retail outlets found during field verification. In addition to the store types included in the sample, tobacco outlet density also included tobacco stores, beer wine and liquor stores, gas stations without convenience, and all other store types that sold tobacco.   | Continuous, number of tobacco outlets per 1000 people in a census tract.             |
| <b>Community physical activity environment</b> | Physical activity resource density | We defined a park as a public place set aside for physical activity and enjoyment. This definition did not include cemeteries, mobile home parks, historic sites, professional stadiums, country clubs, zoos, private parks, private facilities (such as stand-alone baseball or tennis facilities), or stand-alone recreation centers.<br><br>Parks were assigned to census tracts using data from Environmental Systems Research Institute, Inc. (ESRI™) supplemented by county GIS files from the Department of Parks and Recreation. Physical activity resources were located using 2011 data from ReferenceUSA and included both public (e.g., pools and community centers) and private activity resources (e.g., gyms and dance studios). | Continuous, number of physical activity resources per 1000 people in a census tract. |

**Table 2**

Characteristics of consumer and community environments among a sample of retail stores that sold food and tobacco products in three diverse regions of North Carolina, 2011

| Store, Census Tract and County Characteristics, mean (SD) or n (%) | Entire Study Area (n=303) | Buncombe County (n=104) | Durham County (n=110) | New Hanover County (n=89) |
|--|---------------------------|-------------------------|-----------------------|---------------------------|
| <b>Store</b>   |                           |                         |                       |                           |
| <b>Store Type, n (%)</b>   |                           |                         |                       |                           |
| Chain supermarkets & warehouse clubs                               | 45 (14.9)                 | 18 (17.3)               | 14 (11.8)             | 13 (15.7)                 |
| Non-chain supermarkets   | 13 (4.3)                  | 2 (1.9)                 | 8 (7.3)               | 3 (3.4)                   |
| Convenience store with gas station                                 | 162 (53.5)                | 62 (59.6)               | 58 (52.7)             | 42 (47.2)                 |
| Convenience store (without gas)                                    | 45 (14.9)                 | 9 (8.7)                 | 19 (17.3)             | 17 (19.1)                 |
| Pharmacy/drug store <sup>a</sup>                                   | 38 (12.5)                 | 13 (12.5)               | 12 (10.9)             | 13 (14.6)                 |
| <b>Consumer Environment, mean (SD)</b>                             |                           |                         |                       |                           |
| Interior tobacco marketing materials                               | 29.4 (16.6)               | 35.1 (18.5)             | 27.1 (14.3)           | 25.4 (15.0)               |
| Exterior tobacco marketing materials                               | 4.7 (5.9)                 | 4.9 (6.0)               | 4.8 (4.9)             | 4.5 (6.7)                 |
| Healthy food availability score (HFA)                              | 11.0 (7.2)                | 11.8 (7.1)              | 11.1 (6.7)            | 10.0 (7.9)                |
| Walk/bike score  | 2.3 (0.98)                | 2.2 (1.1)               | 2.6 (0.9)             | 2.1 (0.9)                 |
| Physical incivility score  | 1.8 (0.6)                 | 1.8 (0.7)               | 1.6 (0.5)             | 1.9 (0.6)                 |
| <b>Census Tract</b>  |                           |                         |                       |                           |
| <b>Community Environment<sup>b</sup></b>                           |                           |                         |                       |                           |
| Tobacco outlet density <sup>c</sup> , mean (SD)                    | 1.4 (0.8)                 | 1.4 (0.7)               | 1.4 (0.9)             | 1.5 (0.8)                 |
| Low supermarket access <sup>d</sup> , n (%)                        | 156 (51.7)                | 59 (56.7)               | 50 (45.9)             | 47 (52.8)                 |
| Physical activity resource density <sup>c</sup> , mean (SD)        | 0.7 (1.0)                 | 0.7 (1.2)               | 0.4 (0.5)             | 1.0 (1.3)                 |
| <b>Racial/Ethnic Composition<sup>b</sup>, mean (SD)</b>            |                           |                         |                       |                           |
| non-Hispanic Black, %  | 24.2 (24.0)               | 7.7 (9.8)               | 43.4 (22.4)           | 20.2 (21.2)               |
| Hispanic, %  | 8.9 (8.0)                 | 6.1 (5.0)               | 14.5 (9.3)            | 5.2 (4.5)                 |
| <b>Socioeconomic status<sup>b</sup>, mean (SD)</b>                 |                           |                         |                       |                           |
| Families below poverty level, %                                    | 13.7 (13.9)               | 11.1 (8.4)              | 17.1 (17.7)           | 12.8 (13.2)               |
| Median household income, \$  | 46,004 (17,193)           | 45,442 (13,594)         | 46,471 (19,355)       | 46,090 (18,287)           |
| <b>County</b>  |                           |                         |                       |                           |
| Rural population <sup>e</sup> , %                                  | na                        | 24.1                    | 5.6                   | 2.21                      |

<sup>a</sup> Only retail chain pharmacies that sold tobacco products were included in the sample (e.g. CVS, RiteAid, Walgreens)

<sup>b</sup> Community environment measures are based on the census tract where each store is located

<sup>c</sup> Number per 1000 population, activity resource density includes parks and physical activity resources;

<sup>d</sup> at 1 mile in urban areas and 10 miles in rural areas;

<sup>e</sup> US Census Bureau, 2010 Census

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

**Table 3**

Partial Pearson correlation coefficients for associations among and between consumer and community nutrition, tobacco, and physical activity environments, controlling for county, North Carolina, 2011

|                                       | Consumer             |                       |                   |                      |       |                       |                     |   | Community |   |   |   |   |   |   |   |
|---------------------------------------|----------------------|-----------------------|-------------------|----------------------|-------|-----------------------|---------------------|---|-----------|---|---|---|---|---|---|---|
|                                       | 1                    | 2                     | 3                 | 4                    | 5     | 6                     | 7                   | 8 | 1         | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1. Interior Tobacco Marketing         | 1                    |                       |                   |                      |       |                       |                     |   |           |   |   |   |   |   |   |   |
| 2. Exterior Tobacco Marketing         | 0.25 <sup>****</sup> | 1                     |                   |                      |       |                       |                     |   |           |   |   |   |   |   |   |   |
| 3. Healthy Food Availability Score    | -0.13 <sup>*</sup>   | -0.38 <sup>****</sup> | 1                 |                      |       |                       |                     |   |           |   |   |   |   |   |   |   |
| 4. Walk/Bike Score                    | -0.02                | -0.09 <sup>‡</sup>    | 0.08              | 1                    |       |                       |                     |   |           |   |   |   |   |   |   |   |
| 5. Physical Incivility Score          | -0.01                | 0.02                  | 0.03              | 0.07                 | 1     |                       |                     |   |           |   |   |   |   |   |   |   |
| 6. Tobacco Outlet Density             | -0.05                | -0.03                 | 0.08 <sup>‡</sup> | 0.29 <sup>****</sup> | 0.02  | 1                     |                     |   |           |   |   |   |   |   |   |   |
| 7. Physical Activity Resource Density | -0.04                | 0.02                  | -0.03             | 0.33 <sup>****</sup> | 0.01  | 0.27 <sup>****</sup>  | 1                   |   |           |   |   |   |   |   |   |   |
| 8. Low Supermarket Access             | 0.03                 | -0.05                 | 0.10 <sup>‡</sup> | -0.15 <sup>**</sup>  | -0.01 | -0.35 <sup>****</sup> | -0.20 <sup>**</sup> | 1 |           |   |   |   |   |   |   |   |

\*\*\*\* p<0.0001,

\*\* p<0.01,

\* p<0.05,

‡ p<0.25



**Table 4**

Multiple linear regression model of consumer and community environment predictors of healthy food availability in a sample of retail stores that sell food and tobacco products, n=303, North Carolina, 2011

|                                   | <b>B value</b> | <b>SE</b> | <b>P value</b> |
|-----------------------------------|----------------|-----------|----------------|
| Intercept                         | 25.3           | 0.63      | <.0001         |
| Consumer environment              |                |           |                |
| Interior tobacco marketing        | 0.05           | 0.01      | 0.001          |
| Exterior tobacco marketing        | -0.08          | 0.03      | 0.02           |
| Store Type                        |                |           |                |
| Chain supermarkets (reference)    |                |           |                |
| Non-chain supermarkets            | -15.84         | 1.01      | <.0001         |
| Convenience stores                | -18.66         | 0.69      | <.0001         |
| Gas/convenience store             | -18.76         | 0.58      | <.0001         |
| Pharmacy and drug stores          | -15.40         | 0.68      | <.0001         |
| Community environment             |                |           |                |
| Tobacco outlet density            | -0.16          | 0.28      | 0.56           |
| Low supermarket access            | 0.17           | 0.38      | 0.64           |
| Neighborhood demographics         |                |           |                |
| Non-Hispanic Black, %             | -0.02          | 0.01      | 0.14           |
| Hispanic, %                       | 0.01           | 0.03      | 0.85           |
| Median household income, \$10,000 | -0.22          | 0.00      | 0.15           |
| Population, thousands             | -0.20          | 0.11      | 0.08           |
| County                            |                |           |                |
| New Hanover (reference)           |                |           |                |
| Buncombe                          | 0.81           | 0.48      | 0.09           |
| Durham                            | 2.05           | 0.59      | 0.001          |
| Adjusted R-squared                | 0.8378         |           |                |