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Soda, salad, and socioeconomic status: Findings from the Seattle Obesity Study (SOS)

Adam Drewnowski^{a,b}, James Buszkiewicz^{a,*}, Anju Aggarwal^b

^a Department of Epidemiology, School of Public Health, University of Washington, Box 353410, Seattle, WA 98195, USA

^b Center for Public Health Nutrition, School of Public Health, University of Washington, Seattle, WA, USA

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ABSTRACT

Background: Documenting geographic disparities in dietary behaviors can help inform public health interventions at the local level.

Objective: To study and visualize socioeconomic gradient in soda and salad consumption using a geo-localized measure of socioeconomic status in contrast to more traditional measures.

Methods: Geo-localized dietary intake data came from the Seattle Obesity Study I, a population-based sample of King County adults (n=1099). Socio-demographic data and soda and salad consumption frequencies (times/week) were obtained by 20-min telephone survey. Food frequency questionnaire (FFQ) data were used to construct Healthy Eating Index (HEI) scores. Individual residential property values obtained from the King County tax assessor. Multivariable linear regressions examined socioeconomic gradient in the frequency of soda and salad consumption by residential property values, the primary independent variable, in comparison to annual household incomes and educational attainment, with adjustment for age, gender, and race/ethnicity. Geographic disparities in soda and salad consumption by property value metric were illustrated at the census block level using modeled predicted marginal means.

Results: Among all three socioeconomic indicators (income, education and residential property values), residential property values captured strongest gradient in soda and salad consumption. Higher quintiles of residential property values were associated with lower soda and higher salad consumption. Respondents living in the highest quintile of property values – 1.04 fewer sodas per week (95% CI= – 1.87, – 0.21) and 0.89 more salads per week (95% CI= 0.36, 1.42), adjusting for sociodemographic covariates. Residential property values illustrated geographic disparities in soda and salad consumption at the census-block level.

Conclusion: Geo-localized disparities in food consumption patterns by neighborhood can inform current discourse on the socioeconomic determinants of health, while providing a useful tool for targeted interventions at the local level.

1. Introduction

Health and place are intrinsically interconnected. Several studies have examined the ways in which the place of residence can impact diet quality, physical activity, and health outcomes (Drewnowski, Aggarwal, & Rehm, 2014; Renalds, Smith, & Hale, 2010; Caspi, Sorensen, Subramanian, & Kawachi, 2012a; Berrigan, Hipp, & Hurvitz, 2015). The likely impact of the built environment (BE) on diets and health (Renalds et al., 2010) has been measured in terms of access to healthy foods, neighborhood walkability, population density, or land use mix (Caspi, Sorensen, Subramanian, & Kawachi, 2012b). However, evaluating the relation between BE and diet quality can be complicated by unobserved variables, including many related to individual and area

socioeconomic status (SES) (Drewnowski et al., 2014; Berrigan et al., 2015; Caspi et al., 2012b; Drewnowski, Aggarwal, Hurvitz, Monsivais, & Moudon, 2012).

SES is at the confluence of health and place. Individual or household-level factors such as occupation, education, and incomes may determine not only where people live but also how healthy they are (White & Borrell, 2011; Williams & Sternthal, 2010; Iceland & Sharp, 2013). In the US, historical patterns of housing segregation have created concentrated areas of high poverty that are consistently associated with poor health (Lovasi, Bader, Quinn, Neckerman, & Weiss, 2012; Rundle, Quinn, & Lovasi, 2013; Bell, Wilson, & Liu, 2008; Boehmer, Hoehner, Deshpande, Brennan Ramirez, & Brownson, 2007; Burdette & Hill, 2008; Ellaway, Macintyre, & Bonnefoy, 2005). In some studies,

* Corresponding author.

E-mail address: buszkiew@uw.edu (J. Buszkiewicz).

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perceived aspects of BE, such as litter, graffiti, poor sidewalk quality, or its desirable attributes, such as greenery or attractive streets, have been linked to negative or positive health outcomes, respectively (Drewnowski et al., 2014; Caspi et al., 2012b; Jiao, Drewnowski, & Moudon, 2016; Drewnowski, Aggarwal, Tang, & Moudon, 2015; Drewnowski, Aggarwal, Cook, & Stewart, 2016a; Rehm, Moudon, & Hurvitz, 2012).

While the social gradient in diets and health has been amply documented (Darmon & Drewnowski, 2015), fewer studies have assessed the distribution of diet quality or obesity rates at fine geographic resolution. One reason why high-resolution mapping of health outcomes has been limited, is that health data are rarely available below the census tract level (Chaix, Merlo, Evans, Leal, & Havard, 2009; Chaix, Merlo, & Chauvin, 2005). In some studies, choropleth maps of obesity rates by neighborhood were modeled using area-based measures of age, gender, race/ethnicity, education or incomes (Bao, Han, & Hu, 2013; Willett, Hunter, & Stampfer, 1992; Rimm et al., 1993). Choropleth maps are common tools to visualize geospatial data using differences in color shading to denote higher or lower values of a metric in predefined geographic units such as census tracts or zip codes (Bao et al., 2013; Willett et al., 1992; Rimm et al., 1993).

While the geographic distribution of the federal measure of overall diet quality (HEI-2010) has been illustrated previously using property value metrics (Drewnowski et al., 2016a), little is known about individual foods or HEI components. We hypothesize that consumption of salad greens, seafood and whole fruit, which differ widely in both nutrient density and cost, may show differential spatial gradient over consumption of added sugars and fats (Rehm, Monsivais, & Drewnowski, 2015; Monsivais & Drewnowski, 2007). For the present study, we selected frequency of consumption of soda vs. salad, which overlap with HEI components. These two dietary behaviors have been used as the proxy of diet quality in the Behavioral Risk Factors Surveillance Study (BRFSS), and are also frequent targets for fiscal and social policy interventions (Sweetened Beverage Tax Ordinance, 2016; Andreyeva, Long, & Brownell, 2010; Powell, Chriqui, Khan, Wada, & Chaloupka, 2013; Ohri-Vachaspati, Turner, & Chaloupka, 2012; Khalsa, Kharofa, Ollberding, Bishop, & Copeland, 2017; Seguin, Morgan, & Hanson, 2012; King County Department of Natural Resources and Parks, 2016).

The present hypotheses were as follows. First, salad and soda consumption frequencies would follow opposing socioeconomic gradients using residential property values (Rehm et al., 2015; Monsivais & Drewnowski, 2007; Carlson & Frazão, 2014; Drewnowski & Specter, 2004; Aggarwal, Monsivais, & Cook, 2011). Second, residential property values will capture stronger socioeconomic gradient in soda and salad consumption as compared to traditionally used measures of SES i.e. incomes and education. In past studies, residential property values have shown significant associations with overall diet quality measures and obesity rates (Drewnowski et al., 2015; Drewnowski et al., 2016a; Drewnowski, Buszkiewicz, Aggarwal, Cook, & Moudon, 2018). Third, tax parcel property values, obtained from the County tax assessor and aggregated to the census block level, will serve as the objective measure of both individual and area SES and will provide a useful tool to visualize geospatial disparities in soda and salad consumption (Berrigan et al., 2015; Moudon, Cook, Ulmer, & Hurvitz, 2011; Coffee et al., 2013).

2. Materials and methods

2.1. Study participants

The Seattle Obesity Study (SOS I) was based on a stratified random sample of 2001 men and women living in King County, WA (Aggarwal et al., 2011; Monsivais and Drewnowski, 2009). King County zip codes with a higher proportion of low-income households (< \$35,000) as well as African American and Hispanic residents were oversampled

(Drewnowski et al., 2012; Aggarwal et al., 2011; Moudon et al., 2011). The demographics of the SOS I were consistent with 2007 Behavioral Risk Factor Surveillance System (BRFSS) and King County census data (Drewnowski et al., 2012; Aggarwal et al., 2011; Moudon et al., 2011). A series of study instruments were used to collect the variables of interest. All study protocols were approved by the University of Washington Institutional Review Board,

2.2. Sociodemographic and dietary variables

A 20-min telephone survey, modeled on the BRFSS, was used to obtain socio-demographic and dietary data. The demographic variables of interest were age (< 55 and ≥ 55), gender (male and female) and race/ethnicity (White, non-Hispanic and non-White and Hispanic). Education was grouped into a binomial indicator which was equal to 0 if the respondent had a high school education or less and 1 if the respondent has some college education or more. Annual household income was group into three categories < \$50,000, \$50,000–\$99,999, and ≥ \$100,000. Salad consumption was measured via the question: “How often do you eat a green leafy or lettuce salad with or without other vegetables?” Soda consumption was measured via the question: “How often did you drink regular soda or pop that contains sugar. Do not include diet soda.” Respondents replied to these questions by providing a numerical response and frequency – per day, per week, or per month – for their frequency of soda and/or salad consumed. The responses provided per day or per month were computed per week to standardize all responses to frequency per week.

2.3. HEI 2010 scores and its components

Healthy Eating Index 2010 scores (HEI 2010) for each participant were obtained using a standard dietary data collection tool developed by Fred Hutchinson Cancer Research Center (FHCRC), Food Frequency Questionnaire (FFQ). Each SOS participant completed a general-select (G-SEL) version of the validated (Neuhouser, Kristal, McLerran, Patterson, & Atkinson, 1999; Patterson et al., 1999; Kristal, Vizenor, & RP-CE, 2000) FFQ. This FFQ has been widely used in health studies in the past (Drewnowski et al., 2016a; Drewnowski et al., 2018; Neuhouser et al., 1999; Patterson et al., 1999; Kristal et al., 2000; Lippman, Goodman, & Klein, 2005; Masset, Monsivais, Maillot, Darmon, & Drewnowski, 2009). The G-SEL is a semi-quantitative FFQ, collecting information on both frequency (with response categories ranging from “never or less than once per month” to “2+ times per day”) and portion size (small, medium, and large) for 125 food items. The G-SEL also contains additional questions about food purchasing and preparation habits. Completed FFQs were returned by 1318 respondents, for a response rate of 69%, and then were sent to the Nutrition Assessment at FHCRC for dietary analyses (Moudon et al., 2011). Nutrition Assessment at FHCRC uses the Nutrition Data Systems for Research (NDSR) software from the Nutrition Coordinating Center at the University of Minnesota. The NDSR uses the U.S. Department of Agriculture Nutrient Database for Standard Reference as its primary source for nutrient information and the program output provides values for over 150 nutrients, nutrient ratios, and other compounds.

HEI 2010 scores and component scores were calculated for each SOS participant. The HEI 2010 is a measure of diet quality developed to assess compliance with the 2010 Dietary Guidelines for Americans (Guenther, Casavale, & Reedy, 2013; Drewnowski, Aggarwal, Cook, Stewart, & Moudon, 2016b). HEI 2010 scores range from 0 to 100 with higher scores indicating higher diet quality (Guenther et al., 2013; Drewnowski et al., 2016b). The HEI 2010 consists of 12 total components, 9 that measure the adequacy of healthy foods (higher scores indicate higher consumption) and 3 that measure the moderation of unhealthy foods (higher scores indicate lower consumption) (Guenther et al., 2013; Drewnowski et al., 2016b). The 9 adequacy components are: total vegetables (5 points), greens and beans (5 points), total fruit

(5 points), whole fruit (5 points), whole grains (10 points), dairy (10 points), total protein foods (5 points), seafood and plant proteins (5 points) and ratio of polyunsaturated and monounsaturated fatty acids to saturated fatty acids (10 points) (Guenther et al., 2013; Drewnowski et al., 2016b). The 3 moderation components are: refined grains (10 points), sodium (10 points) and energy from solid fat, alcohol and added sugars (SoFAAS) (20 points) (Guenther et al., 2013; Drewnowski et al., 2016b).

2.4. Residential property values: A geospatial measure of SES

Residential property values at the tax parcel level were obtained from the King County tax assessor. The home address information for each participant was geocoded using ArcGIS and linked to the tax assessor parcel data. These data capture the assessed value, which is the approximate market value of properties. For parcels with multiple residential units (e.g., apartments), the assessed value was divided by the number of residential units on that parcel. The detailed methodology to develop this metric has been published previously (Drewnowski, et al., 2016b). This variable of residential property has been established as a measure of SES or wealth in past SOS studies (Drewnowski et al., 2016a; Moudon et al., 2011). For analytical purposes, the residential property value metric was converted into quintiles.

2.5. Visualization of dietary variables by residential property values

Of the total number of SOS participants ($n = 2001$), 1994 were able to be geocoded. King County contains 22,800 census blocks with at least one residential unit and of these 1657 census blocks contained at least 1 SOS I participants with a mean of 1.20 ± 0.56 (range 1 to 8). Roughly 85% of these census blocks had only 1 SOS I participant. Using ArcGIS Desktop release 10 (Brillat-Savarin, 1825) the tax parcel map was overlaid on census blocks and property values were then aggregated spatially by the census block in which the tax parcel fell. These were then broken into evenly distributed quintiles. Some census blocks did not contain any residential units and therefore could not be assigned to a residential property value quintile. These census blocks included those located in the Industrial District and Boeing Airfield, the University of Washington campus, among others.

2.6. Statistical analyses

The present analyses were restricted to those SOS participants who returned the FFQ, without extreme energy intakes reported (< 500 kcal/d or > 5000 kcal/d), had data on geocoded location and provided socio-demographic information. No significant socio-demographic differences were observed between FFQ responders and non-responders. The final analytical sample consisted of 1099 respondents; however, two respondents did not respond to the soda consumption question on the FFQ and were therefore excluded from the analysis of soda but included in the analysis of salad consumption per week.

A series of multivariable regression analyses were conducted. First, to evaluate associations between our primary independent variable, residential property values, and primary dependent variables, frequency of soda and salad consumed weekly, in comparison to more traditional measures of socioeconomic status: education and income, we ran four linear regression models. Models 1 through 3 estimated weekly consumption of soda vs. salad by educational attainment, annual household income, and residential property value quintiles, respectively, adjusting for age, gender, and race/ethnicity. Model 4 included the same primary independent variable, residential property value quintiles, adjustments as model 3 but simultaneously adjusted for educational attainment. As a secondary analysis, we sought to assess how weekly consumption of soda and salad tracked with overall HEI scores and its individual HEI components. To do this, we ran linear

regression models to estimate HEI 2010 component and total score using frequency of soda and salad consumption per week, adjusting for age, gender, race/ethnicity, educational attainment, and residential property value quintiles. All analyses were conducted using Stata version 14 (StataCorp, 2015).

2.7. Data visualization

For this analysis, we generated high resolution choropleth maps of soda and salad consumption by census block using average residential property value per dwelling unit by census block based on adjusted marginal means of SOS I respondents from the previously described model 4. The resolution of a geospatial data refers to the size of the primary geographic unit. For example census blocks are the smallest geographic unit used by the U.S. Census Bureau and are smaller than census block groups which are, in turn, smaller than census tracts. In the City of Seattle, there are 131 census tracts, 482 block groups, and 11,512 census blocks (City of Seattle Office of Planning and Community Development, 2018). Residential property values at the tax parcel level for all residential units in Seattle were aggregated by census block and were split into quintiles. Each census block was assigned marginal mean soda and salad consumption per week for that quintile of property value from SOS under the observation that quintiles of property values for the SOS I sample closely mirrored that of the greater Seattle-King County region. All GIS mapping and visualizations were conducted using ArcGIS Desktop release 10 (ESRI, 2011).

3. Results

3.1. Participants

SOS participants were largely female (62%), 55 years or older (55%), and White (85%). More than half of SOS participants had annual household incomes of \$50,000 or more (62%) and more than three-fourths had some college education or more (83%). High education and incomes are typical of residents of the City of Seattle. Table 1 shows mean soda and salad consumption frequencies by socio-demographics. Mean soda consumption was 1.58 times/week (equivalent to 147 to 220 Kcal/week for an 8 to 12 fl oz serving of original Coca Cola reported more frequent soda consumption per week than women (1.27 ± 3.94), and non-whites and/or Hispanic residents (2.59 ± 4.98) reported more frequent soda consumption than white, non-Hispanic residents (1.41 ± 4.18). Soda consumption was inversely and significantly related to residential property values with a two-fold difference in soda consumption between the bottom (2.25 ± 5.73) and the top quintile (1.11 ± 3.17) of property values. There was no significant difference in the frequency of soda consumption by age, income, or education.

Mean salad consumption was relatively high (3.78 times/week). Women consumed more salad (4.04 ± 2.97) than did men (3.35 ± 2.37) while those adults age 55 and older (4.02 ± 2.60) consumed more than adults less than 55 years of age (3.50 ± 2.97). Adults with a some college education or more (3.86 ± 2.81) consumed salad more frequently per week than those with a higher school education or less (3.41 ± 2.59). There were also significant differences in weekly salad consumption by annual household income with adults earning \$50,000 to \$99,999 (4.03 ± 2.85) or \$100,000 or more (3.88 ± 2.09) consuming more salad per week than those earning $< \$50,000$ annually (3.48 ± 3.10). There was no significant difference in salad consumption by race/ethnicity.

3.2. Property values and soda and salad consumption

Table 2a displays the adjusted linear regression estimates for soda consumption by income (model 1), education (model 2), residential property value quintiles (models 3 and 4). In models 1 and 2, education and income were not significantly associated with soda consumption,

Table 1
Sample distribution of socio-demographic characteristics and mean frequency of consumption (times per week) of soda and salad.

	Soda					Salad				
	N	%	Mean	SD	P-value	N	%	Mean	SD	P-value
Overall	1097	100.0	1.58	4.32		1099	100.0	3.78	2.78	
Sex										
Female	682	62.2	1.27	3.94	0.003	685	62.3	4.04	2.97	< 0.001
Male	415	37.8	2.08	4.85		414	37.7	3.35	2.37	
Age										
< 55	493	44.9	1.73	4.24	0.293	493	44.9	3.50	2.97	0.002
55+	604	55.1	1.46	4.38		606	55.1	4.02	2.60	
Race and ethnicity										
White, non-Hispanic	938	85.5	1.41	4.18	0.001	939	85.4	3.85	2.79	0.069
non-White and Hispanic	159	14.5	2.59	4.98		160	14.6	3.41	2.72	
Education										
High school education or less	182	16.6	2.02	4.93	0.132	181	16.5	3.41	2.59	0.046
Some college education or more	915	83.4	1.50	4.19		918	83.5	3.86	2.81	
Annual household income										
< \$50,000	415	37.8	1.74	4.08	0.502	414	37.7	3.48	3.10	0.014
\$50,000 to \$99,999	394	35.9	1.39	4.03		394	35.9	4.03	2.85	
≥ \$100,000	288	26.3	1.60	4.68		291	26.5	3.88	2.09	
Residential property values										
Quintile 1 (\$19,907-199,000)	221	20.1	2.25	5.73	0.016	221	20.1	3.10	2.75	< 0.001
Quintile 2 (\$200,000-250,000)	217	19.8	1.41	4.02		219	19.9	3.78	2.75	
Quintile 3 (\$250,440-314,000)	223	20.3	1.42	3.47		222	20.2	3.84	2.82	
Quintile 4 (\$315,000-426,000)	217	19.8	1.51	4.64		218	19.8	3.90	3.11	
Quintile 5 (\$427,000-2,440,000)	219	20.0	1.11	3.17		219	19.9	4.31	2.31	

% are column percentages

Notes. There are two nonresponses missing responses to the soda consumption question. Residential property values are at the tax parcel level. P-values were obtained via univariate testing of mean soda and salad consumption per week using t-test for all binomial predictors (sex, race and ethnicity, and own or rent current residence) and analysis of variance (ANOVA) for all categorical predictors with 3 or more groups (age, education, annual household income, and residential property value quintile).

Table 2a
Multivariable linear regression analyses estimating mean frequency of soda consumption (times per week) by residential property values at the tax parcel level.

Residential property values at tax parcel	Frequency of soda consumption (times per week) (n = 1097)			
	Model 1	Model 2	Model 3	Model 4
	Estimate	Estimate	Estimate	Estimate
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Education				
High school or less	Reference	-	-	Reference
Some college or more	-0.52 (-1.21, 0.17)	-	-	-0.36 (-1.06, 0.35)
Annual household income				
< \$50,000	-	Reference	-	-
\$50,000 to \$99,999	-	-0.42 (-1.02, 0.18)	-	-
≥ \$100,000	-	-0.23 (-0.90, 0.44)	-	-
Property Values				
Quintile 1 (\$19,907-199,000)	-	-	Reference	Reference
Quintile 2 (\$200,000-250,000)	-	-	-1.04 (-1.84, 0.24)	-1.04 (-1.84, -0.34)
Quintile 3 (\$250,440-314,000)	-	-	-1.10** (-1.90, -0.31)	-1.06** (-1.86, -0.26)
Quintile 4 (\$315,000-426,000)	-	-	-0.96** (-1.77, -0.16)	-0.92* (-1.72, -0.11)
Quintile 5 (\$427,000-2,440,000)	-	-	-1.25** (-2.05, -0.45)	-1.17** (-1.99, -0.36)

Notes. All models adjust for individual level gender, age, and race/ethnicity. P-values are determined by Wald tests for each point estimate. There are two non-responses missing responses to the soda consumption question.

***p < 0.001.
* p < 0.05.
** p < 0.01.

Table 2b

Multivariable linear regression analyses estimating mean frequency of salad consumption (times per week) by residential property values at the tax parcel level.

Residential property values at tax parcel	Frequency of salad consumption (times per week) (n = 1099)			
	Model 1	Model 2	Model 3	Model 4
	Estimate	Estimate	Estimate	Estimate
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Education				
High school or less	Reference	–	–	Reference
Some college or more	0.54 (0.10, 0.98)	–	–	0.37 (-0.08, 0.82)
Annual household income				
< \$50,000	–	Reference	–	–
\$50,000 to \$99,999	–	0.69*** (0.31, 1.08)	–	–
≥ \$100,000	–	0.67** (0.24, 1.09)	–	–
Property Values				
Quintile 1 (\$19,907–199,000)	–	–	Reference	Reference
Quintile 2 (\$200,000–250,000)	–	–	0.65** (0.14, 1.16)	0.65* (0.14, 1.16)
Quintile 3 (\$250,440–314,000)	–	–	0.76** (0.25, 1.27)	0.72** (0.21, 1.23)
Quintile 4 (\$315,000–426,000)	–	–	0.79** (0.28, 1.30)	0.74** (0.22, 1.25)
Quintile 5 (\$427,000–2,440,000)	–	–	1.14*** (0.62, 1.65)	1.06*** (0.54, 1.58)

Notes. All models adjust for individual level gender, age, and race/ethnicity. P-values are determined by Wald tests for each point estimate.

* p < 0.05.

** p < 0.01.

*** p < 0.001.

adjusting for demographics (age, gender, and race/ethnicity). In model 3, higher levels of residential property value were linked to lower soda consumption, with respondents in quintile 5 (\$427,000–\$2,440,000) consuming soda a little over 1 additional time per week compared to quintile 1 (\$19,907–\$199,000) (–1.25, 95% CI= –2.05, –0.45), adjusting for demographics. In model 4, which adjusts for demographics and educational attainment, higher levels of residential property value were still linked to lower soda consumption although estimates were somewhat attenuated with respondents in fifth quintile of residential property values consuming soda 1.17 (95% CI= –2.05, –0.45) fewer times per week than those in the first quintile of property values. As a secondary analysis, jointly adjusting for educational attainment, annual household income, and residential property values quintiles showed that residential property values predicted a larger share of the variance in soda consumption based on standardized beta estimates (data not shown).

Table 2b displays the adjusted linear regression estimates for salad consumption by income (model 1), education (model 2), residential property value quintiles (model 3 and 4). In model 1, education was not significantly associated with salad consumption. In model 2, those respondents with annual household incomes between \$50,000 to \$99,999 (0.69, 95% CI=0.31, 1.08) and ≥\$100,000 (0.67, 95 CI=0.24, 1.09) consumed salad weekly significantly more frequency than those with household income < \$50,000, adjusting for demographics. In model 3, higher levels of residential property value were also associated with higher salad consumption, with those respondents in quintile 5 consuming salad a little over 1 additional time per week compared to quintile 1 (1.14, 95% CI=0.62, 1.65), adjusting for demographics. In model 4, additionally adjusting for educational attainment slightly attenuated the association between property value quintile and salad consumption with respondents in the fifth quintile of property values consuming approximately one more salad (1.06, 0.54, 1.58) compared to those respondents in the first quintile of property values. As with

soda consumption, residential property values predicted a larger share of the variance in salad consumption compared to either education or annual household income based on standardized beta estimates (data not shown).

3.3. Soda and salad consumption by census block

Estimated marginal means from fully adjusted model 4 were used to create modeled distributions of soda and salad consumption frequencies by Seattle census blocks. Fig. 1 shows the modeled map for soda consumption, whereas Fig. 2 shows the modeled map for salad consumption. There were clear differences by neighborhood: Areas with higher residential property values, such as to the west coast along the Puget Sound and along Lake Washington to the east were associated with higher salad consumption and lower soda consumption. Areas with lower property values showed the reverse. Fig. 3 shows the geospatial distribution of median residential property values by census block for the City of Seattle.

3.4. Soda and salad consumption and HEI 2010

Table 3 shows the relations between the two BRFSS screener questions and HEI 2010 scores and components. Multivariable linear regression analyses adjusted for age, sex, race/ethnicity, education and property value quintiles. Higher soda consumption frequencies were associated with lower HEI scores for total fruit, whole fruit, total vegetables, greens and beans and the total HEI 2010 score was lower (–0.46, 95% CI= –0.59, –0.33). Conversely, higher salad consumption frequencies per week were associated with more total fruit, whole fruit, total vegetables, greens and beans and low fat dairy and total HEI 2010 scores were higher (0.64, 95% CI=0.44, 0.85).

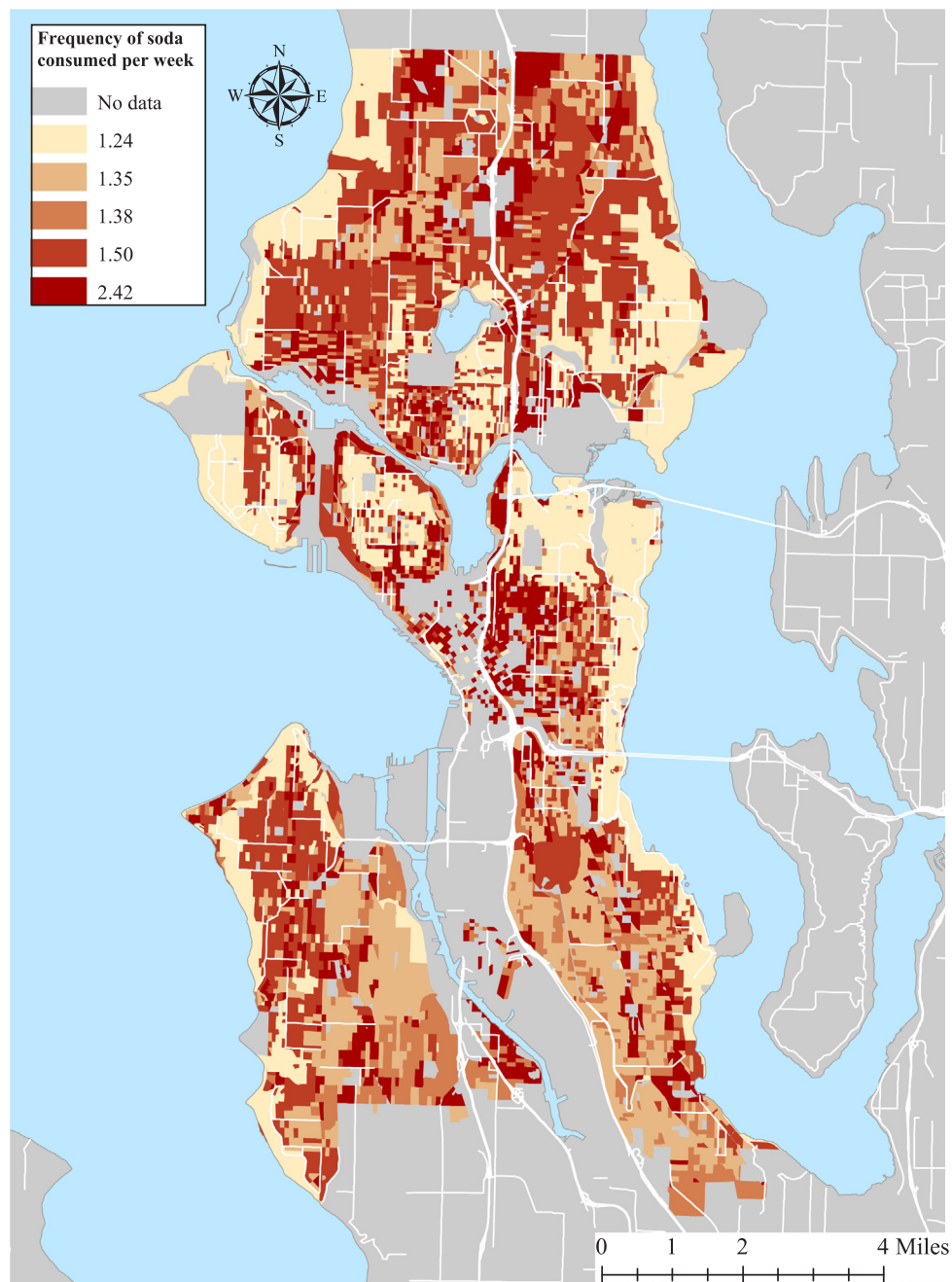


Fig. 1. Estimated mean frequency of consuming soda per week by census block based on multivariate models regressing self-reported consumption on quintiles of residential property values at the individual level, controlling for age, gender, race/ethnicity, and educational attainment, Seattle, Washington. *Notes.* Census blocks within the city limits of Seattle with missing data do not contain residential housing units.

4. Discussion

Soda and salad consumption frequencies followed opposing SES gradients. Whereas salad consumption was clearly associated with higher property values, soda consumption was associated with lower property values. Residential property values were also more consistently predictive and displayed a clear gradient for both dietary measures in comparison to either educational attainment or annual household income. The geographic disparities in soda and salad consumption patterns were illustrated by maps at the census block level. Soda consumption (Fig. 1) tended to be higher in areas with higher concentrations of low residential property values whereas salad consumption was higher in areas characterized by higher property values. For comparison purposes, property values in the City of Seattle are

provided in Fig. 3.

Soda consumption frequencies in the SOS sample were lower than the national estimates. About 10% of the SOS adults consumed 1 or more sodas daily (data not shown), as compared to 53% of men and 41% of women who consumed regular soft/other drinks nationally (LaComb, Sebastian, Wilkinson, & JD, 2011). By contrast, salad consumption frequencies in the SOS sample were consistent with national data. About 22% of the SOS sample consumed 1 or more salads daily (data not shown) compared to just over 20% nationally (Fiechtner, Block, & Duncan, 2013).

The secondary analysis of soda and salad consumption frequencies in relation to total and component HEI 2010 scores showed, as expected, that salad consumption was associated with higher consumption of vegetables and fruit. By contrast, higher soda consumption

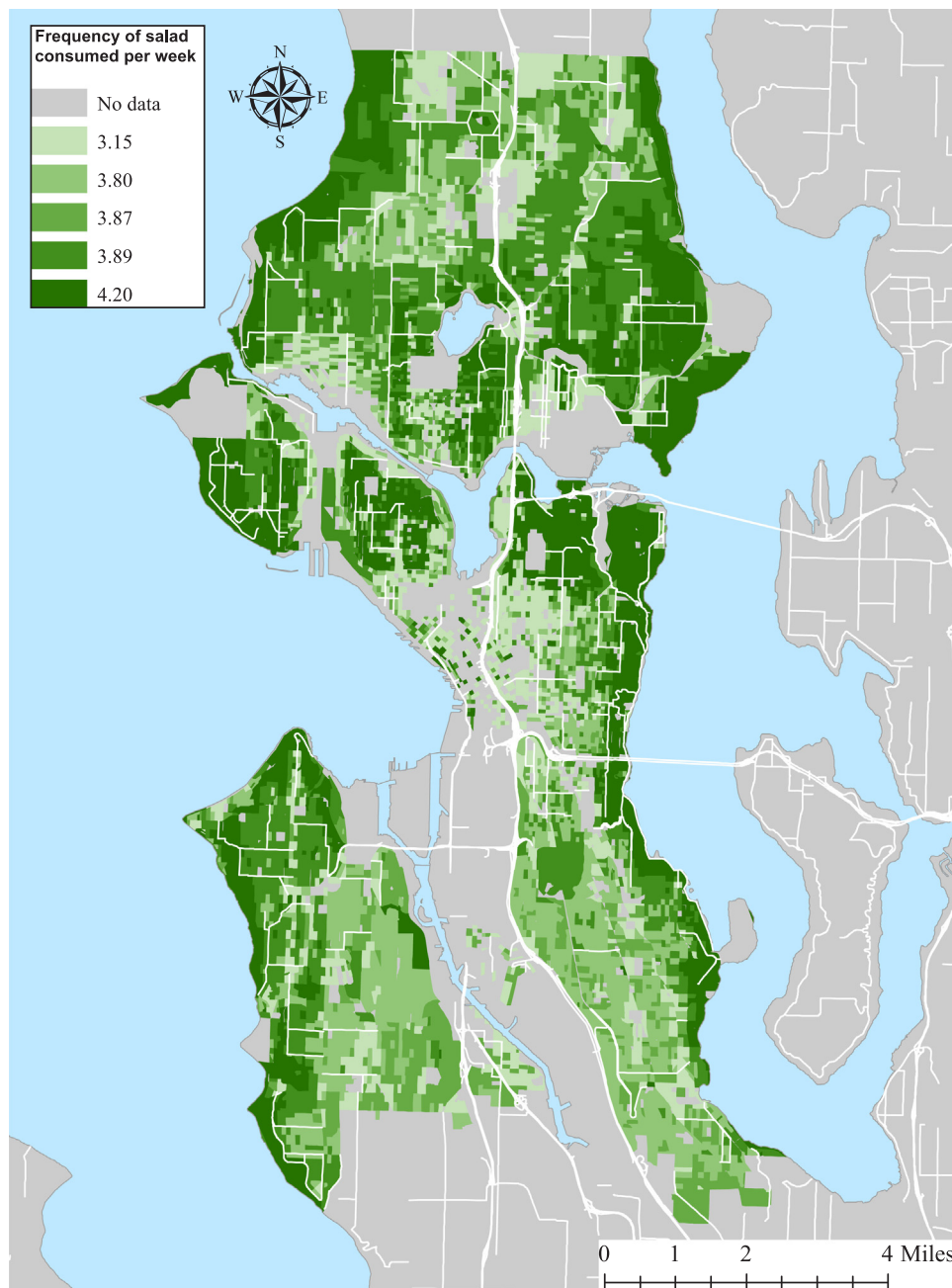


Fig. 2. Estimated mean frequency of consuming soda per week by census block based on multivariate models regressing self-reported consumption on quintiles of residential property values at the individual level, controlling for age, gender, race/ethnicity, and educational attainment, Seattle, Washington. *Notes.* Census blocks within the city limits of Seattle with missing data do not contain residential housing units.

frequencies were associated with lower consumption of vegetables and fruit. The BRFSS one-item survey questions were intended as rough screeners of diet quality and continue to be used by many health jurisdictions. The present results show that the two screeners showed good correlations with more formal measures of diet quality obtained using FFQ dietary intakes and HEI components.

The present use of tax parcel residential property values as an objective measure of individual- or area SES deserves a mention. First, tax parcel data are not subject to biases created by administrative boundaries and may be aggregated to any desired level, from census blocks to census block groups and census tracts. US Census data are not typically publicly available below census tract level (Berrigan et al., 2015; Chaix et al., 2009; Chaix et al., 2005; Moudon et al., 2011). Second, property values can be of value in studies of socioeconomic disparities in diets

and health (Drewnowski et al., 2015; Carlson & Frazão, 2014; Moudon et al., 2011; Davis & Carlson, 2015). They may capture net worth and SES more consistently and with a clearer gradient than either self-reported educational attainment or household incomes (Lovasi et al., 2012; Rundle et al., 2013; Duncan, Spence, & Mummery, 2005; Fiechtner et al., 2013; Duncan et al., 2012; Rundle, Bader, Richards, Neckerman, & Teitler, 2011; Wall, Larson, & Forsyth, 2012; Dunton, Kaplan, Wolch, Jerrett, & Reynolds, 2009; Auchincloss et al., 2009). In past studies, key characteristics of “obesogenic” neighborhoods were associated with lower property values (Drewnowski et al., 2014; Drewnowski et al., 2018; Drewnowski et al., 2016b).

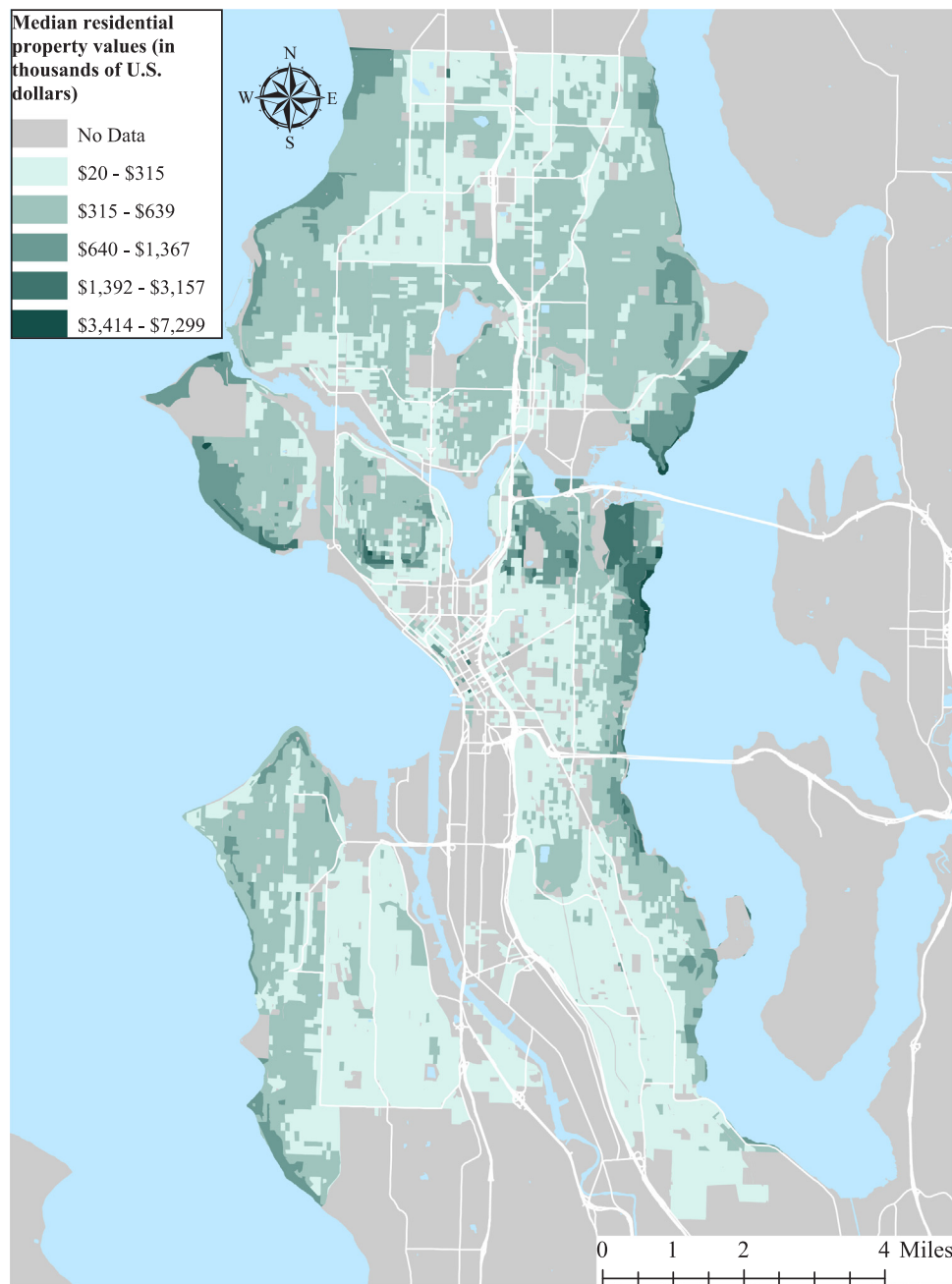


Fig. 3. Distribution of quintiles of median tax parcel residential property values at the census block level, Seattle, Washington. Notes. Census blocks within the city limits of Seattle with missing data do not contain residential housing units.

5. Policy implications

Soda and salad are at the forefront of dietary interventions and national food and nutrition policies. Excess consumption of sugary soft drinks is viewed as a major obesity risk (Malik, Pan, Willett, & Hu, 2013; Luger et al., 2017). Nearly two-thirds of all states have implemented some form of tax on sugary beverages through a variety of mechanisms, including excise taxes or sales taxes (Sorensen, Mullee, & Duncan, 2017). In 2016, four cities approved new taxes on sugary drinks: Boulder, Colorado and three cities in California (San Francisco, Oakland and Albany) (Willmsen, 2017). The California measures proposed a tax of a penny per ounce, whereas Boulder proposed a tax of two cents per ounce (Willmsen, 2017; Drenkard, 2012). The two-cent per ounce tax on sugary drinks in Seattle exempted diet beverages and bottled water (Willmsen, 2017).

As more states and municipalities seek to develop targeted interventions for better health, they will need place-based tools to identify high-risk or high-need communities. Analyses of National Health and Nutrition Examination Survey data have already pointed to a social gradient: added sugar was consumed more often by lower-income groups (Kit, Fakhouri, Park, Nielsen, & Ogden, 2013). Sweetened beverage consumption was higher among younger males, lower-income adults, and some racial/ethnic groups (Bleich, Vercammen, Koma, & Li, 2018). The present method of visualizing dietary behaviors by census block can assist local health jurisdictions and policy advocates to improve the targeting of policy interventions. Detailed maps can identify neighborhood level needs that would normally be missed by city-level surveillance.

The present approach also provides a useful illustration of which communities are in most need of interventions that seek to increase

Table 3

Multivariable linear regression analyses to estimate Healthy Eating Index components and total scores using mean frequency of soda and salad consumption (times per week) with and without adjustment of socio-demographic factors.

HEI Metric	Frequency of soda consumption (times per week) (n = 1097) HEI Component/Total Score (95% CI)	Frequency of salad consumption (times per week) (n = 1099) HEI Component/Total Score (95% CI)
Total fruit	-0.03** (-0.05, -0.01)	0.03* (0.00, 0.06)
Whole fruit	-0.04** (-0.06, -0.02)	0.05* (0.02, 0.07)
Total vegetables	-0.03*** (-0.04, -0.01)	0.10*** (0.08, 0.12)
Greens and beans	-0.05*** (-0.07, -0.03)	0.18*** (0.15, 0.20)
Whole grains	-0.03 (-0.07, 0.01)	-0.04 (-0.10, 0.02)
Dairy	0.04 (-0.08, 0.00)	-0.02 (-0.08, 0.04)
Total protein foods	0.00 (-0.01, 0.01)	0.01* (0.00, 0.03)
Seafood & plant proteins	-0.02** (-0.04, -0.01)	0.03** (0.01, 0.06)
Fatty acids	-0.05* (-0.09, -0.01)	0.18*** (0.18, 0.24)
Refined grains	-0.01 (-0.04, 0.01)	0.06*** (0.03, 0.10)
Sodium	0.04 (0.00, 0.08)	-0.17*** (-0.23, -0.11)
Added sugars & solid fats	-0.21*** (-0.26, -0.16)	0.22*** (0.14, 0.31)
Total score	-0.46*** (-0.59, -0.33)	0.64*** (0.44, 0.85)

Notes. P-value are determined by Wald tests for each point estimate. All models adjusted for education, property value quintiles, gender, age, and race/ethnicity. There are two nonresponses missing responses to the soda consumption question.

* p < 0.05.

** p < 0.01.

*** p < 0.001.

fruit and vegetable consumption (Drenkard, 2012). To that end, policies that promote access to healthy and affordable foods, via targeted subsidies, may achieve the greatest progressive shifts in diet quality.

6. Conclusions

Residential property values are a valuable metric for studies of social and economic determinants of health. Using residentially property values to predict dietary behaviors and health allows for the mapping of geographic disparities allows the visualization at the neighborhood level. These methods can help in the targeting of local interventions by researchers, policy makers, and local health jurisdictions.

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Conflict of interest

Adam Drewnowski has received grants, contracts, honoraria, and consulting fees from numerous food and beverage companies and other commercial and nonprofit entities with interests in diet quality and health. The University of Washington has received grants, donations,

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