Environmental Disparities in the Objectively and Longitudinally Measured Local Food Environments of Urban Older Adults

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Abstract

Background: Valid measures of local food environments are needed to quantify disparities in the availability of healthy foods and estimate the effect of built environments on health. Limited measures are available to describe the fluctuation of food retail environments over time, and how food environments are utilized by older adults.

Purpose: This study measured neighborhood environments of older adults living in Brooklyn, NY, using an objective, prospective audit tool in order to document variations in the availability of food retailers and other neighborhood resources over a two-year period. Additionally, neighborhood utilization patterns, which may mitigate exposure to the built environment, were assessed using surveys of participating older adults.

Methods: Older adults enrolled in the Cardiovascular Health of Seniors and the Built Environment study in New York City (NYC) between 2009-2011 completed surveys in person at baseline and two years later (n=1,318). Auditors documented food retailers located on NYC streets within 300-meters of each participant's home, within six months of baseline surveys, and two years later.

Results: Most participants walked to food stores, purchased food less than 0.5 mile from home, and consumed meals at home. Changes to food retail environments were observed by race and ethnicity, with decreases in bodegas (b= -1.28, standard error (SE) = 0.18) and liquor stores (b= -0.19, SE 0.05) in the buffer zones of white participants compared with that of black participants. Increases in supermarkets were observed in both white (b= 0.27, SE 0.07) and Latino buffer zones (b= 0.28, SE 0.08).

Conclusions: Changes in food environments varied by areas where Black, White, and Hispanic participants lived. Understanding the variation of exposure to local food environments over time, and how the exposures may be mediated by behaviors, will lead to more precision in exposure assignment within this area of environmental and health science.

1. Introduction

Exposure assessment of environmental toxins, typically include the estimation of dose, timing and route of human exposure in relation to the onset of disease. Critical to this assessment is the knowledge of the fate (half-life) and transport (movement) of environmental toxins of interest as they contaminate air, water, soil, dust and/or food. With this knowledge, environmental scientists, toxicologists, and epidemiologists have been able to determine human carcinogens and other adverse human health effects of hundreds of environmental compounds [1]. Recently, distinctions have been made between the environmental assessment of chemicals in the natural environment (i.e. air, water) and human exposures from man-made environments, referred to as built environments.

One aspect of built environments includes food retailers and most studies evaluating their effect on health have been cross-sectional with little appreciation for the dose or timing of human exposure as it pertains to the diet-related diseases being measured. Not surprisingly, the empirical evidence is mixed in terms of the effect of local food environments and human health [2]. The hazard identification of any particular food environment is also limited by a paucity of studies describing the fluctuation of local food environments over time, which would inform the 'fate' (opening and closing of stores) and 'transport' (composition of stores within areas) of these dynamic retail environments.

For practical and ethical reasons, studies that measure the health effects of environmental exposures are typically non-experimental and therefore, are susceptible to biases related to observational studies. Objective exposure measurements to environmental toxins, such as biomarkers, eliminate some of these concerns, yet these types of exposure measurements for local food environment do not exist. This adds further concern about the potential confounding and misclassification that may affect the exposure assessment in local food environment studies. Still, before the dose and timing can be estimated, a clearer understanding of the fate and transport of food environments is necessary. There are two methodological issues that are particularly problematic when measuring food environments. First, there has been an assumption that these retail environments are constant over time, such that a single measure of exposure can represent long-term environmental exposure sufficient to affect disease through dietary intake. Researchers who aim to measure associations between food environments and health have relied on this supposition [2-4]. However, the stability of retail environments varies among neighborhoods by both race and income [5]. The second issue is that local food environment studies have almost exclusively used secondary data sources to determine the location and definition of store types. These sources include government (e.g., state and city records) and commercial databases (e.g., Dun and Bradstreet; InfoUSA). Studies have found poor validity from commercial databases when compared to ground-truthing methods, with commercial databases generally underestimating the number, incorrectly defining - and misplacing – retailers, with errors most pronounced in neighborhood with a primarily black population [6-9]. For example, Powell et al. [9] found commercial data undercounted 24%-29% of supermarkets and grocery stores, with an additional 10%-18% error in the accuracy of outlet type assignment. Efforts to validate secondary sources with remote sensing technologies, such as Google maps, remain unpromising because they have produced consistent underestimates of supermarkets and stores to date [10].

In addition to the validity of exposure assessment to local food environments, the impact of neighborhood environments on the health of older adults has received little attention, despite evidence showing this population is more vulnerable to the impact of their neighborhood environments on their health, because older adults rely on their immediate vicinity for procuring food [11-13]. This is a significant and increasing portion of the United States population. In 2001, 41.4 million people age 65 years or older resided in the United States, an 18% increase from a decade earlier, and four-fifths of this population reside in metropolitan areas. [14]. Therefore, the aim of this study was to describe: (a) variation in the local food environments, over time, where older adults reside; and (b) utilization patterns that may affect the impact of the exposure to neighborhood environments, using both an objectively measured prospective audit of food stores and restaurants in Brooklyn, New York, and participant surveys that measured the use of local food resources by older adults.

2. Methods

2.1. Study population

Older adults, 59-99 years of age were enrolled into the Cardiovascular Health of Seniors and the Built Environment study in waves between January 2009 and June 2011, then followed for two years. Participants were sampled from New York City community centers serving older adults living in all areas of Brooklyn and selected neighborhoods in Queens (along the Brooklyn/Queens border). Once enrolled, neighborhood environments were defined by creating buffer zones with a radius of 300-meters (roughly 3.75 city blocks) around participants' residential addresses, using ArcGIS v9.3 (Environmental Systems Research Institute (Esri); Redlands, CA). A

300-meter buffer zone was selected *a priori* because: (a) the target population for this study was older adults; (b) walking or public transportation was expected to be the main transportation sources among New York City seniors; and (c) the difficulty in carrying groceries home increases with distance (a distance of more than four city blocks in any direction was assumed to be burdensome for the target population). The study was approved by the Icahn School of Medicine at Mount Sinai Institutional Review Board.

2.2. Audit method

The New York City Department of City Planning (DCPLION-2009) street segment files were layered onto the buffer zones, resulting in maps of whole and partial street segments located within the buffer zone. Street segments are typically road lengths between two adjacent intersections or an intersection and a dead-end. Continuous roads, such as freeways, are also segmented. For simplicity, street segments are referred to as *streets*. Streets identified within buffer zones were highlighted on paper maps and assigned to trained auditors who documented the food retailers (defined in section 2.3) located on each street through a walking audit. If only part of a street was located in a buffer zone, the entire street was audited. Auditors were instructed to document the location of the retailer on the audit maps where the entrance of the establishment was located. All decisions about the type of food retailer were made based on observations from the street and noted on the maps with unique icons.

Some streets were excluded from the walking audit because they were either vehicular only, such as highways (e.g., Brooklyn Queens Expressway) or another type of street where features of interest were not likely to be located (e.g., Brooklyn

Bridge). Additional excluded streets were coded in the DCPLION file as railroads, private streets, alleys, paths, connectors, exit/entrance ramps, or faux streets. Of the 22,739 street segments located in participants' buffer zones, a total of 4,330 streets were excluded from the walking audit. In total, 16,047 Brooklyn-based and 2,362 Queens-based streets (as buffer zones extended into Queens for participants living on the Brooklyn-Queens border) were evaluated.

All maps were coded and entered electronically into a street segment database. Subsequently, food retailer types were summed by participant, resulting in a total number of each of the nine types of food environment features for each participant. The protocol called for all streets to be audited within a six-month window of the baseline interview and again within six-months of the 2nd year follow-up exam. Individuals were excluded if both time points were not audited, resulting in the exclusion of 135 of the enrolled 1,453 cohort members.

2.3. Definitions of retailers

Nine types of food retailers were included. Food retailers that **sell foods and beverages that can be prepared at home** included: bodegas, liquor stores, small grocery stores, and supermarkets. The retailers that provide food that **is prepared and generally eaten away from home** included: convenience stores, franchised fast food restaurants, street food vendors, and taverns and bars. The definitions used for the neighborhood audits are provided in alphabetical order below.

Bodegas are small stores selling food items ranging from beer, soda, snack food and sometimes canned goods, dairy, and other food items. *Convenience Stores* are stores that are similar to Bodegas but contain mainly beer, sodas and snack foods and are often, but not always, attached to a gas station. *Franchised Fast Food Restaurants* include any chain fast food restaurant such as McDonalds, Burger King, or Taco Bell. *Liquor Stores* are any store where the only type of beverage sold is alcoholic. *Restaurants* include both full service and limited service restaurants where customers can sit at tables. This includes a heterogeneous group of food service places from places such as coffee shops, pizza shops and ethnic restaurants to high-end restaurants. *Small Grocery Stores* are food stores that are smaller than supermarkets but carry a larger selection of foods to prepare at home than bodegas. In general, these stores are not chain stores, (although Union Market, for instance, where there is more than one location is considered a small grocery store due to the smaller size of the stores compared with larger supermarket chains). *Street Food Vendors* includes street vendor selling <u>only</u> food, whether meals, pretzels, candy, coffee/pastries, and includes food trucks. *Supermarkets* are any large chain food store that sells a large selection of foods such as the following New York City purveyors: C-town, Associated, Pathmark, Food Emporium, Key Food, Gristedes, Gourmet Garage, Trader Joes, or Fairway. *Tavern/Bars* include any place where the main purpose of the establishment is to serve alcoholic beverages and includes lounges, bars, pubs, taverns, and clubs.

2.4. Demographic and socioeconomic data

Demographic and socioeconomic information was collected though interviewer administered questionnaires. Demographic information included gender, age at the baseline survey, race and ethnicity (Black, White, Latino and Other). Other race included Native Americans and South East Asians. The highest level of education

attained, marital status, and household income were also collected.

2.5. Neighborhood utilization and transportation data

In order to understand how older adults obtain food in their local area, participants were queried regarding: (a) having a NY State driver's license; (b) owning a car; (c) usual transportation used to go to food stores, and (d) use of food delivery services. The participants were also asked the distance to where most food shopping was conducted and how many meals per day were cooked and eaten at home versus away from home during the past 12 months.

2.6 Statistical analysis

Descriptive statistics were calculated for the demographic and food shopping behaviors reported by participants. For the evaluation of local food environments, the number of each type of food retailer was calculated on each street within each buffer zone. The number of each type of retailer was summed within buffer zones for the baseline audit (2009-2011). Means and standard deviations of the number of each type of retailer located in buffer zones at the first audit were calculated by the race/ethnicity of participants. For each street within buffer zones, the difference in number of each type of food retailer was compared between the 2009-11 and 2011-13 audits. Street differences were summed within buffer zones, resulting in the total 2-year difference for each retailer by buffer zone. Differences were evaluated for outliers for each type of retailer and buffer zones; implausible differences were removed from retailer-specific analyses (no more than 5% of the data were excluded for any given retailer type). Streets were

categorized as stable if the difference in retailer type was zero. If the difference was negative, the area was categorized as having a decrease in the retailer type and positive differences were categorized as an increase. The percent of retailer types that were stable, increased or decreased was calculated. Linear regression was used to calculate the association between the 2-year change in food retailers and race/ethnicity. Models were calculated separately for each type of retailer and indicator variables were created for the four race/ethnicity groups using Blacks participants as the reference. All models were adjusted for participant's household income (<$30,000 (1), $30,000 or more (0)). All analyses were conducted using SAS version 9.3 (SAS Systems, Cary NC).

3. Results

The study population consisted of older adults primarily between the ages of 65-84 years (74.3%) and mostly women (76.2%) (Table 1). Most participants self-identified as Black or Latino (69%) and reported moderate household incomes of less than $30,000 per year (65%). Most participants were not married (74%) and completed high school or less (64%).

More than half of participants reported they walked to food stores (60.3%) and that food shopping was done less than ½ mile from home (66.0%) (Table 1). Although a third of the population reported having a valid driver's license, most of the participants did not own a car (74.4%) and few older adults reported using delivery services to obtain groceries. Over 80% of participants reported 1-3 meals per day are cooked at home and very few meals were eaten away from home with the same frequency (18.5%).

Table 1. Sociodemographic Characteristics and Food Shopping
Behaviors of the Study Population (N=1,318)

	N	%
Age at first exam		
59-64	214	16.2
65-74	570	43.2
75-84	410	31.1
85-99	124	9.5
Race and Ethnicity		
Black, non-Hispanic	623	47.3
Hispanic	289	21.9
White, non-Hispanic	367	27.8
Other race	39	3.0
Gender		
Female	1,004	76.2
Male	314	23.8
Household Income[1]		
< $30,000	862	65.4
$30,000 or more	352	26.7
Marital Status[1]		
Single	267	20.3
Married	266	20.2
Separated	83	6.3
Divorced	213	16.2
Widow	410	31.1
Living with Partner	16	1.2
Highest Level of Education[1]		
Elementary	135	10.2
Middle School	174	13.2
High School	533	40.4
Trade/Vocational	75	5.7
College/University	291	22.1
Other	36	2.7
New York State driver's license[1]		
No	759	57.6
Yes	452	34.3

Own a car[1]

No	981	74.4
Yes	231	17.5

How do you usually get to your food stores?[2]

Walk	795	60.3
Subway	41	3.1
Bus	149	11.3
Cab	38	2.3
Car	268	20.3
I don't shop	54	4.1
Access -A-Ride	46	3.5

How often do you have groceries delivered?[1]

Always	63	4.8
Most of the time	40	3.0
Some of the time	146	11.1
Never	954	72.4

How far from home is the place where you do most food shopping?[1]

Less than 1/2 mile	870	66.0
1/2 - 1 mile	200	15.2
1-2 miles	80	6.1
more than 2 miles	75	5.7

Over the past 12 months, how often were meals cooked and to be eaten at home?[1]

None	58	4.4
Less than 1 per day	96	7.3
1/day	296	22.5
2/day	492	37.3
3/day	280	21.2

Over the past 12 months, how many meals were cooked and to be eaten away from home?[1]

None	589	44.7
Less than 1 per day	384	29.1
1/day	147	11.2
2/day	78	5.9
3/day	19	1.4

[1]*Do not include missing data;* [2]*Categories are not mutually exclusive*

The walking audit evaluated 66% of all Brooklyn streets, and 5% of streets located in the borough of Queens (along the Brooklyn/Queens border). The average number of food retailers that sell foods and beverages that can be prepared at home at the first audit are presented in Table 2 by race and ethnicity. Bodegas and small grocery stores were the most prevalent types of food retailers in all areas; however, there were fewer bodegas and small grocery stores in buffer zones where white seniors lived compared with black and latino participants.

For prepared food businesses, restaurants were the most prevalent, with similarities in the average number of each type of retailer across all areas by race. The exception was buffer zones where Latino participants lived; these contained roughly 50% more of each retailer than the other areas. Areas where white seniors lived contained the fewest franchised fast food establishments, however all areas, on average, contained less than one franchised fast food retailer per buffer zone.

Table 2. Average number of food retailers within 300 meter buffer zone at the baseline assessment by race and ethnicity: Brooklyn New York 2009-2011 (N=1,318)

	Black (N=623)		Latino (N=289)		White (N=367)		Other (N=39)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
For Home Preparation								
Bodega	4.99	3.76	5.30	3.42	2.64	3.05	5.00	3.57
Liquor Store	0.74	1.01	1.12	1.11	0.77	1.10	0.79	1.00
Small Grocery Store	3.46	3.45	5.48	5.01	2.64	2.91	2.79	3.16
Supermarket	1.01	1.10	1.14	1.13	0.84	1.21	2.05	1.99
Away from Home								
Convenience Store	0.36	0.79	0.37	0.74	0.49	1.08	0.59	1.29
Franchised Fast Food	0.96	1.51	0.86	1.55	0.74	1.26	0.92	1.46
Restaurant	6.15	5.94	9.77	7.69	6.22	7.80	6.46	6.37
Street Vendor	0.28	1.06	1.50	3.69	1.07	2.83	0.26	1.14
Tavern and Bar	0.46	1.06	0.95	1.43	0.69	1.47	0.49	1.07

SD=standard deviation

During the re-evaluation of buffer zones two years after the baseline exam, areas were assessed for the stability of food retailers. Figure 1 describes the changes by type of retailer. The greatest amount of change was with the opening and closing of bodegas, small grocery stores and restaurants. For bodegas, there was a large increase over the course of the audit period (56.5%) and a large decrease in small grocery stores (55.3%). There was also a greater, albeit small, proportion of restaurant openings compared with closings. For supermarkets, only about half of the buffer zones remained constant. Although there were changes in the other food retail categories, most remained roughly two-thirds stable.
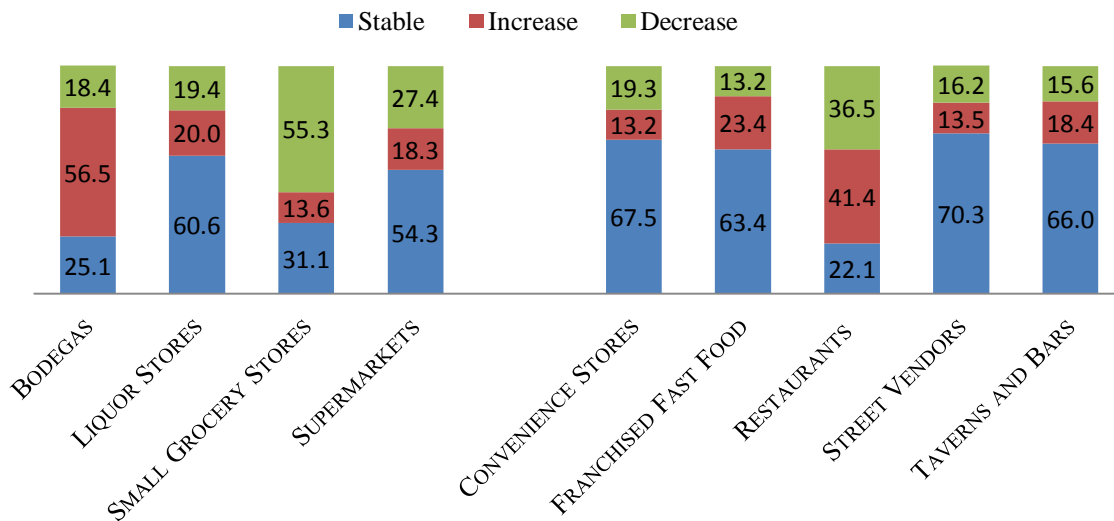
Figure 1. Proportion % of buffer zones with an increase, decrease or stable 2-year change in food retailers (Brooklyn New York, 2011-2013)

Changes to food retail environments were not distributed evenly across buffer zones, and difference were observed by the race and ethnicity of participants. For example, compared to areas where black seniors lived, significant decreases in both bodegas (b= -1.28, standard error (SE)= 0.18) and liquor stores (b= -0.19, SE 0.05) were observed in buffer zones where white participants resided (Table 3). In the areas where white seniors lived there was also a significant increase in small grocery stores (b= 1.02, SE 0.18) and supermarkets (b= 0.27, SE 0.07). A similar difference for supermarkets was observed for Latino buffer zones (b= 0.28, SE 0.08).

With regard to places to purchase food away from home, buffer zones of white participants had fewer new franchised fast food establishments (b= -0.32, SE 0.08) and street vendors (b=- 0.24, SE 0.09) compared with those of black participants and a greater number of new restaurants (b= 1.91, SE 0.26) at the time of the second audit. Conversely, buffer zones of Latino participants showed an increase in franchised fast food establishments (b= 0.32, SE 0.09), bars and taverns (b= 0.47, SE 0.08), as well as restaurants (b= 1.31, SE 0.28) compared with buffer zones of black participants. Buffer zones where the other race group resided also had a positive change in the number of restaurants, but a decrease in the number of supermarkets compared to the buffer zones where black participants lived.

Table 3. Associations between 2-year change in local food environments and race, ethnicity.

	Black		Latino			White			Other		
	i	se	b	se	p-value	b	se	p-value	b	se	p-value
For Home Preparation											
Bodegas	1.77	0.15	-0.12	0.21	0.5754	-1.28	0.18	<.0001*	-0.67	0.47	0.1492
Liquor Stores	0.01	0.05	0.04	0.06	0.4517	-0.19	0.05	0.0006*	-0.12	0.13	0.3681
Small Grocery Stores	-1.65	0.15	-0.30	0.20	0.1365	1.02	0.18	<.0001*	0.23	0.45	0.6066
Supermarkets	-0.27	0.06	0.28	0.08	0.0002*	0.27	0.07	0.0001*	-1.01	0.18	<.0001*
Away from Home Preparation											
Convenience Stores	-0.09	0.05	0.08	0.06	0.1850	0.00	0.06	0.9388	-0.22	0.14	0.1139
Fast Food Franchise	0.28	0.07	0.32	0.09	0.0004*	-0.32	0.08	<.0001*	-0.06	0.21	0.7899
Restaurants	-0.04	0.22	1.31	0.28	<.0001*	1.91	0.26	<.0001*	1.40	0.64	0.0296*
Street Vendors	-0.06	0.08	-0.18	0.10	0.0843	-0.24	0.09	0.0119*	0.03	0.23	0.9090
Taverns and Bars	0.00	0.06	0.47	0.08	<.0001*	-0.06	0.07	0.4113	0.05	0.18	0.7750

*i=intercept; b=parameter estimate; se=standard error; * statistically significant at a=0.05. Adjusted for income.*

4. Discussion

These findings show that urban older adults rely primarily on walking to purchase food and that food shopping is conducted close to home. Moreover, most meals are prepared at home making the availability of supermarkets and small grocery stores an important food retail market for this population. Overall, this study has documented a considerable amount of change in local food environments within a relatively short amount of time. Interestingly, changes in the presence of larger chain food retailers (i.e. supermarkets and franchised fast food restaurants) were observed as were changes in smaller food establishments, such as bodegas and restaurants. However, greater positive changes to the food environment – increases in food retailers – took place in the areas were the white participants lived, including fewer closing of supermarkets and small grocery stores, as well as fewer openings of franchised fast food restaurants and bodegas.

This study described changes in urban food retail markets over time, suggesting these environments are not stable and, in fact, vary with disparities in fluctuation across neighborhoods of color. This evidence fills a gap in our understanding of access to food in urban environments, and provides the groundwork for developing more sensitive exposure definitions in studies aimed to measure the effect of these built environments on health behaviors and disease prevention, which include: a) objective measures of food retail environments; b) longitudinal assessments; and c) a geographical scale of neighborhood use that is practical for the targeted study population.

However, it remains unclear how behaviors modify individuals' exposure to these dynamic retail environments. What is clear is that reasons for shopping outside of local areas to obtain food are multifactorial including, but not limited to, the absence of desired foods locally available, the cost and quality of local food options and perceptions of local food retailers [11, 15, 16].

While these factors modify the scale of shopping environments for some groups of people and, subsequently, affect individual exposure to local environments, they do not change the need to accurately measure what types of food establishments are conveniently and reliably available within neighborhood environments [17]. Measurements of local food environments have included the locations of retail food outlets, as well as assessments of the availability, price and placement of foods within stores [18]. In-store measures of food are predicated on the presence of certain food store types. For example, supermarkets are assumed to carry the largest selection of fresh produce compared to other types of food retailers. However, the absence of these types of retailers in some black urban neighborhoods prevented the in-store assessment of the price and variety of produce from these large retailers [19]. Hence, the proximity of food retailers to residents continues to be a concern for public health.

This study highlights the need to improve the exposure assessment of food environments; however there are some limitations to be noted. First, the 300-meter buffer zones are equivalent to 0.19 miles and, although most participants reported food shopping less than ½ mile from home, it is possible that 300 meters underestimates the reasonable geography to be used for food shopping among this older adult population. Because of the population density in New York City, and overlapping 300-meter buffer zones within the study population, we were able to conduct a sensitivity analysis to measure the average change in retailers within a larger (400-meter) buffer zone, as a comparison. In general, changes in the retail environment were in the same direction for each race and ethnic group and remained statistically significant. In some cases the magnitude of differences increased. However, the sensitivity analysis is limited by a smaller proportion of the streets within buffer zones being audited, which may affect the 400-meter results. Second, this study took place in New York City and may not be generalizable to older adults living in suburban and rural communities. Third, the two-year change in local food environments may have little clinical significance in the development of diet-related diseases because these illnesses take many years to develop. This exposure assessment may be more proximally applied to health behaviors, such as food shopping or eating, where residents have repeated daily exposure to these environments within a two year period. Fourth, this evaluation happened to coincide with one of the most significant economic downturns in United States history, and therefore, may not represent usual changes in food retail environments. Finally, this study aims to more precisely measure one aspect of the built environment: local food environments. It does not provide an exposure assessment, rather describes the environmental factors that are necessary to measure in order to estimate dose, timing and route of exposure.

Utilization was measured in order to understand potential mitigation of exposure to local food environments. It is worth noting that in terms of mitigating exposure, convenience has been documented as the greatest consideration in making food

choices among people with low incomes and people of color [20]. Retailers understand the influence of convenience and consider it "germane" to their business, targeting it at multiple levels to influence purchasing. Best performing retailers aim to make it easy for customers to search for and purchase products within stores, while also prioritizing convenient access to stores [21]. Convenience is also a fundamental principal used in public health and has been used to promote health [22]. This is supported by recent examples, such as residential relocation studies showing that changes in urban planning by developers (e.g. making the physical environment more accessible to walking or biking) prompt positive health behaviors [23-26], and increases in healthier food options by neighborhood retailers increases purchasing of these foods [27-31].

4.1. Conclusions

It is projected that there will be 92 million older adults living in the United States in 2060 [14]. It is also well recognized that for older adults, reduction in daily caloric intake associated with aging makes meeting dietary recommendations even more challenging than for younger populations [32,33]. Therefore, effectively measuring environmental factors that can enrich the ability for this population to meet clinical dietary recommendations to manage disease is particularly relevant for the broader American population. Targeted interventions can be improved with better-quality exposure assessments of local food availability and utilization patterns. A move towards more precise exposure assessments will require the incorporation of objectively measured features of local food environments; measurements taken longitudinally for lengths of time long enough to influence disease status (or simulation for these lengths of time) and refined geographies of the reasonable parameters of exposure considering the older adult population, available transportation and type of area being studied (rural/urban/suburban). These methods will reduce current biases that may make associations between diet-related diseases and local food environments difficult to detect.

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Conflicts of financial interest.

None of the authors have conflicts of financial interest.

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