



Change in an urban food environment within a single year: Considerations for food-environment research and community health

Sean C. Lucan^{a,*}, Andrew R. Maroko^b, Aurora Jin^c, Aixin Chen^c, Charles Pan^c, Geohaira Sosa^d, Clyde B. Schechter^a

^a Department of Family and Social Medicine, Albert Einstein College of Medicine | Montefiore Health System, Bronx, NY, United States

^b Department of Environmental, Occupational, and Geospatial Health Sciences, CUNY Graduate School of Public Health and Health Policy, New York, NY, United States

^c Albert Einstein College of Medicine, Bronx, NY, United States

^d Queens College, Queens, NY, United States

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ABSTRACT

Past research on food-environment change has been limited in key ways: (1) considering only select storefront businesses; (2) presuming items sold based on businesses category; (3) describing change only in ecological terms; (4) considering multi-year intervals. The current study addressed past limitations by: (1) considering a full range of both storefront and non-storefront businesses; (2) focusing on items actually offered (both healthful and less-healthful varieties); (3) describing individual-business-level changes (openings, closings, changes in offerings); (4) evaluating changes within a single year. Using a longitudinal, matched-pair comparison of 119 street segments in the Bronx, NY (October 2016–August 2017), investigators assessed all businesses—food stores, restaurants, other storefront businesses (OSBs), street vendors—for healthful and less-healthful food/drink offerings. Changes were described for individual businesses, individual street segments, and for the area overall. Overall, the number (and percentage) of businesses offering any food/drink increased from 45 (41.7%) in 2016 to 49 (45.8%) in 2017; businesses newly opening or newly offering food/drink cumulatively exceeded those shutting down or ceasing food/drink sales. In 2016, OSBs (gyms, barber shops, laundromats, furniture stores, gas stations, etc.) together with street vendors represented 20.0% and 27.3% of businesses offering healthful and less-healthful items, respectively; in 2017, the percentages were 31.0% and 37.0%. While the number of businesses offering healthful items increased, the number offering less-healthful items likewise increased and remained greater. If change in a full range of food/drink availability is not appreciated: food-environment studies may generate erroneous conclusions; communities may misdirect resources to address food-access disparities; and community residents may have increasing, but unrecognized, opportunities for unhealthy consumption.

1. Introduction

Increasing rates of diet-related diseases (Lee et al., 2011; Ljungvall and Zimmerman, 2012; Flegal et al., 2012; Ogden et al., 2012; Gao et al., 2016) correspond to changes in local food environments. Over a decade (1981–1990), local food environments in four California cities showed progressive increases in both number and concentration of businesses offering food/drink (Wang et al., 2008). Over more than three decades (1971–2008), food environments in four Massachusetts towns showed the same (James et al., 2017). The studies demonstrating these findings (as well as most prior studies linking food environments to diet or health outcomes Caspi et al., 2012; Cobb et al., 2015;

Malambo et al., 2016) included only select storefront businesses.

Beyond select storefronts (e.g., food stores, restaurants), community sources of food/drink also include “other storefront businesses” (OSBs) (Farley et al., 2010; Lucan et al., 2018a,b,c; Caspi et al., 2016; Wright et al., 2015; Basch et al., 2016). OSBs offering food/drink (e.g., gyms, laundromats, barber shops) increased by 75.0% over five years in one study (Lucan et al., 2018a). From 2010 to 2015, increases were also seen in the numbers of general grocers and specialty food stores; overall, 30% more businesses offered food/drink on 22% more of sampled streets (Lucan et al., 2018a).

While prior studies suggest general shifts in community food/drink offering, findings are limited in four critical ways. First, community

* Corresponding author.

E-mail addresses: slucan@yahoo.com (S.C. Lucan), andrew.maroko@sph.cuny.edu (A.R. Maroko), ajin@mail.einstein.yu.edu (A. Jin), achen5@mail.einstein.yu.edu (A. Chen), cpan1@mail.einstein.yu.edu (C. Pan), clyde.schechter@einstein.yu.edu (C.B. Schechter).

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sources of food/drink may also include non-storefronts—e.g., street vendors (Valdez et al., 2012; Lucan et al., 2014; Tester et al., 2010; Lucan et al., 2011). Second, not all businesses of a given type (e.g., “convenience store”) may sell the same kinds of items. Third, businesses may change their offerings over time. Fourth, important changes may occur over spans shorter than multi-year intervals.

Changes in food environments, as well as how such changes are measured, have implications for both food-environment research and community health. For food-environment research, food/drink “exposures” might be mischaracterized if stability is presumed when change is occurring; the result could be spurious findings and false conclusions. For community health, the extent, stability, and healthfulness of food/drink offering might be misidentified; resources could be allocated to apparent “food deserts” (areas lacking healthful food) that do not actually exist, or be withheld from emerging “food swamps” (areas overwhelmed by less-healthful food) that escape notice.

In the current study, investigators conducted a detailed evaluation of food-environment change. The study considered a full range of storefront and non-storefront food/drink sources, as well as multiple categories of foods and drinks. Making repeated observations within a single year, the intent was to describe short-term changes in food/drink availability: from individual businesses; on given streets; and for an area overall. The goal was to understand implications for both food-environment research and community health.

2. Methods

2.1. Sample

As part of a broader research project, investigators collected data on food/drink availability in multiple neighborhoods across the Bronx, NY. For neighborhoods in one high-poverty, majority-Black area of the Bronx (NYC Health, 2018), data was collected at two time points: October 2016 and August 2017. The area, spanning about one mile diameter, included 119 contiguous street segments (sections of street between two intersections). These street segments represented the study sample.

3. Data collection

Along sampled street segments, investigators used methods for data collection developed through prior work (Lucan et al., 2018b,c; Lucan et al., 2013a,b) to answer a range of food-environment questions (Lucan et al., 2014; Lucan et al., 2018a; Lucan et al., 2019; Lucan et al., 2020). Data collection entailed walking each side of each sampled street segment, at each observation time, to identify businesses. For each identified business, investigators recorded the following information: business name (or business description for unnamed street vendors); business type (e.g., “pizzeria,” “hardware store,” “produce cart”); and street address (or closest address for street vendors).

Investigators also recorded the availability (“yes/no” based on product displays, signage, or menus) of any specific food/drink in specific categories. Categories, informed by dietary guidelines (Dietary Guidelines for Americans 2015-2020, 2016) and other research (Mozaffarian et al., 2011), included the following: *healthful foods* (fruits or vegetables, whole grains, nuts); *less-healthful foods* (*refined sweets* like cookies and candies, *salty/fatty fare* like fried foods and processed meats); *healthful drinks* (water, unsweetened milk); and *less-healthful drinks* (sugar-sweetened beverages and alcohol). Other foods/drinks were either not assessed or considered neither “healthful” nor “less-healthful”—in some cases due to scientific debate (Miranda et al., 2015; Zhong et al., 2019; Nicklas et al., 2012; Wojcicki and Heyman, 2012; Raben and Richelsen, 2012; Ludwig, 2009; Drouin-Chartier et al., 2020). Further details about food/drink categorization appear elsewhere. (Lucan et al., 2018b,c).

Four investigators collected data at each observation time—early

October 2016 and early August 2017. One investigator participated at both observation times, providing continuity to the project. Data collection occurred via smartphone using REDCap (Research Electronic Data Capture) version 6.1.0 (Vanderbilt University, Nashville, TN) (Harris et al., 2009).

4. Data reliability

Prior to actual data collection, all investigators were trained by the lead author. As in prior studies (Lucan et al., 2013a,b; Lucan et al., 2014; Lucan et al., 2018a,b,c; Lucan et al., 2019; Lucan, et al., 2020), training included several days of practice assessments, culminating with reliability checks. Each investigator in 2016 and each investigator in 2017 separately assessed a sample of 25 street segments, first alone, then with a partner. Inter-rater agreement was exceptionally high for both individual and partnered assessments; discrepancies occurred in <0.6% of recorded values. Discrepancies that did occur were almost exclusively inconsequential (e.g., “Vaya” vs. “Vaya modern mexican” for recorded business name; “iced tea” vs. “Snapple” for recorded example of *sugary drinks* from a specific take-out restaurant). Reasons for substantive discrepancies (e.g., missing the option for brown-rice substitution on a menu) were addressed before the start of actual data collection.

4.1. Data analysis

Analyses involved matched comparisons of observations from 2016 to those from 2017. Comparisons were at three levels: individual businesses, street segments, and the study area overall. For individual businesses, comparisons used “strict matches” (Lucan et al., 2018a; Lucan et al., 2013a) businesses on the same street segment, at both observation times, having the exact same name or consistent name (e.g., “Cessay Hair Braiding” vs. “Ceesay Design African Hair Braiding”). For both street segments and the study area overall, comparisons between 2016 and 2017 were based on aggregate business-level data.

As in prior studies (Lucan et al., 2018a,b,c; Lucan et al., 2013a), businesses were categorized as one of four types: (1) *food stores* – storefronts primarily focused on selling grocery items (e.g., supermarkets, grocery stores, convenience marts) as well as specialty food stores like butcher shops, green grocers, and fish markets; (2) *restaurants* – storefronts primarily focused on selling prepared foods including various fast-food, take-out, and table-service eateries; (3) *OSBs* – other storefront businesses not primarily focused on food/drink selling like laundromats, hardware stores, and barber shops, (4) *street vendors* – non-storefront sellers like ice-cream trucks, produce stands, and lunch carts. Please see footnotes to Appendix – Table A1 for specific examples.

For individual-business-level changes, analyses included counts (and percentages) for opening, shutting down, starting to offer food/drink, or ceasing food/drink sales. At the street-segment level, analyses included counts (and percentages) for shifts in food/drink availability. Area-level analyses included counts (and percentages) for food/drink availability both by business category and by street segment.

Analyses at all levels incorporated considerations of healthful and less-healthful items. At the area level, analyses incorporated considerations of specific food/drink categories. Changes in the availability of items from specific food/drink categories were quantified by percentage differences; differences in percentages, both for businesses and for street segments, were calculated along with 95% confidence intervals. Confidence intervals were calculated using bootstrap resampling (Stine, 1990; Efron and Tibshirani, 1986) to account for incompletely matched data (some businesses newly opening and some businesses shutting down between assessment times). All statistics were calculated using Stata/MP2 version 15.1 (2017 StataCorp LP, College Station, TX).

Table 1

Area-level changes in “yes/no” food availability by both food category and businesses category—2016 versus 2017 on 119 street segments in the Bronx, NY.

Characteristics of businesses ^a	2016		2017		Difference 2017–2016 (%age points)	[95% CI]
	n	(%) ^b	n	(%) ^b		
Overall businesses	108	(100.0)	107	(100.0)	–	–
offering any food	45	(41.7)	49	(45.8)	(4.1)	[–3.4, 11.7]
offering any fruits or vegetables	37	(34.3)	34	(31.8)	(–2.5)	[–8.3, 3.4]
offering any whole grains	20	(18.5)	21	(19.6)	(1.1)	[–5.2, 7.4]
offering any nuts	16	(14.8)	23	(21.5)	(6.7)	[1.6, 11.7]
offering any refined sweets	38	(35.2)	44	(41.1)	(5.9)	[–0.6, 12.5]
offering any salty/fatty fare	37	(34.3)	37	(34.6)	(0.3)	[–5.1, 5.7]
Food Stores	17	(15.7)	16	(15.0)	(–0.8)	[–3.2, 1.7]
offering any food	17	(100.0)	16	(100.0)	(0.0)	[0.0, 0.0]
offering any fruits or vegetables	17	(100.0)	16	(100.0)	(0.0)	[0.0, 0.0]
offering any whole grains	13	(76.5)	11	(68.8)	(–7.7)	[–37.4, 22.0]
offering any nuts	12	(70.6)	15	(93.8)	(23.2)	[3.1, 43.2]
offering any refined sweets	16	(94.1)	16	(100.0)	(5.9)	[–5.0, 16.8]
offering any salty/fatty fare	17	(100.0)	16	(100.0)	(0.0)	[0.0, 0.0]
Restaurants	15	(13.9)	13	(12.1)	(–1.7)	[–5.3, 1.8]
offering any food	15	(100.0)	13	(100.0)	(0.0)	[0.0, 0.0]
offering any fruits or vegetables	14	(93.3)	13	(100.0)	(6.7)	[–5.9, 19.2]
offering any whole grains	3	(20.0)	6	(46.2)	(26.2)	[2.3, 50.0]
offering any nuts	0	(0.0)	2	(15.4)	(15.4)	[–4.1, 34.9]
offering any refined sweets	13	(86.7)	12	(92.3)	(5.6)	[–15.7, 27.0]
offering any salty/fatty fare	15	(100.0)	13	(100.0)	(0.0)	[0.0, 0.0]
OSBs	71	(65.7)	71	(66.4)	(0.6)	[–5.1, 6.4]
offering any food	11	(15.5)	15	(21.1)	(5.6)	[–2.7, 14.0]
offering any fruits or vegetables	4	(5.6)	3	(4.2)	(–1.4)	[–6.3, 3.5]
offering any whole grains	4	(5.6)	4	(5.6)	(0.0)	[–3.7, 3.7]
offering any nuts	4	(5.6)	6	(8.5)	(2.8)	[–1.0, 6.6]
offering any refined sweets	9	(12.7)	14	(19.7)	(7.0)	[–0.8, 14.9]
offering any salty/fatty fare	5	(7.0)	8	(11.3)	(4.2)	[–0.5, 8.9]
Street vendors	5	(4.6)	7	(6.5)	(1.9)	[–3.7, 7.5]
offering any food	2	(40.0)	5	(71.4)	(31.4)	[–21.3, 84.1]
offering any fruits or vegetables	2	(40.0)	2	(28.6)	(–11.4)	[–66.3, 43.4]
offering any whole grains	0	(0.0)	0	(0.0)	(0.0)	[0.0, 0.0]
offering any nuts	0	(0.0)	0	(0.0)	(0.0)	[0.0, 0.0]
offering any refined sweets	0	(0.0)	2	(28.6)	(28.6)	[–6.4, 63.5]
offering any salty/fatty fare	0	(0.0)	0	(0.0)	(0.0)	[0.0, 0.0]

OSBs = other storefront businesses not primarily focused on food/drink selling like laundromats, hardware stores, and barber shops (please see footnotes to Appendix – Table A1 for more specific examples).

^a Businesses are restricted to those open at the time of assessments; only open business allowed for exact determination of food offerings.

^b Column percentage; denominators for column percentages are the n values in the preceding table row having the lesser degree of indentation.

5. Results

Table 1 shows area-level changes in food availability, 2016 to 2017, by food category and by business category. Absolute counts were small, precluding 95% confidence of change in most cases. For example, although the number (and percentage) of businesses offering *any* food increased from 45 (41.7%) in 2016 to 49 (45.8%) in 2017, the confidence interval was wide. A tighter confidence interval, more convincing of a definitive increase, was seen for businesses offering nuts: nuts were available from 16 businesses (or 14.8% of the total) in 2016 vs. 23 businesses (21.5% of the total) in 2017. Despite an increase in nut sellers, the number of businesses offering *any* healthful foods more generally (nuts, whole grains, fruits or vegetables) did not change between years; there were 37 businesses offering healthful foods in both 2016 and 2017 (values not shown in table). While three fewer businesses offered fruits or vegetables in 2017 than 2016 (decreasing 37 to 34) and six more businesses offered refined sweets (increasing 38 to 44), neither change could be asserted with $\geq 95\%$ confidence. The number of businesses offering *only* foods that were less-healthful (i.e., *only refined sweets* and/or *salty/fatty fare*) increased—from six businesses (5.6% of the total) in 2016 to 10 businesses (9.3% of the total) in 2017 (values not shown in table; 95% CI for the difference: –1.7 to 9.3 percentage points). The observed increase in businesses offering *only* foods that were less-healthful was due entirely to two types of businesses: OSBs and street vendors.

OSBs and street vendors both increased 2016 to 2017 (n = 11 to n = 15 and n = 2 to n = 5, respectively). Conversely, food store and

restaurants both decreased 2016 to 2017 (n = 17 to n = 16 and n = 15 to n = 13, respectively). Although more food stores offered nuts in 2017 (increasing from 12 to 15), and more restaurants offered whole grains (increasing from 3 to 6), these healthful changes were exceeded by increases in OSBs and street vendors offering less-healthful foods; in particular, the combined count of OSBs and street vendors offering refined sweets nearly doubled (from 9 businesses to 16).

Table 2 shows area-level changes in drink availability. Area-level drink availability showed a net increase from 2016 to 2017 by a single business. The only kind of drink for which availability from a greater number of sellers could be determined with than 95% confidence was milk; milk was available from 20 businesses in 2016 and 27 businesses in 2017 (a 6.7 percentage-point increase). The increase in milk availability was mostly due to restaurants; none offered milk in 2016, five (all fast-food outlets) offered milk in 2017. Equaling or exceeding the number of businesses offering milk (in every business category in both years) was the number of businesses offering sugar-sweetened beverages.

Table 3 details changes between 2016 and 2017 in terms of businesses newly opening, newly shutting down, or starting or ceasing to sell food/drink. The number of businesses no longer offering *any* healthful items (due to business closures or ceasing sales) matched the number of businesses no longer offering *any* less-healthful items. The number of businesses newly offering healthful items (due to business openings or initiating sales) matched the number of businesses newly offering less-healthful items. Among businesses already offering *any* food/drink, one started offering healthful items that previously had not,

Table 2

Area-level changes in “yes/no” drink availability by both drink category and businesses category—2016 versus 2017 on 119 street segments in the Bronx, NY.

Characteristics of businesses ^a	2016		2017		Difference 2017–2016 (%age points)	[95% CI]
	n	(%) ^d	n	(%) ^d		
Overall businesses	108	(100.0)	107	(100.0)	–	–
offering any drink ^b	40	(37.0)	41	(38.3)	(1.3)	[–5.1, 7.6]
offering any water	39	(36.1)	39	(36.4)	(0.3)	[–6.1, 6.8]
offering any milk	20	(18.5)	27	(25.2)	(6.7)	[1.5, 11.9]
offering any sugar-sweetened beverages	39	(36.1)	38	(35.5)	(–0.6)	[–6.6, 5.4]
offering any alcohol	12	(11.1)	10	(9.3)	(–1.8)	[–5.4, 1.9]
Food Stores	17	(15.7)	16	(15.0)	(–0.8)	[–3.3, 1.8]
offering any drink ^b	17	(100.0)	16	(100.0)	(0.0)	[0.0, 0.0]
offering any water	17	(100.0)	16	(100.0)	(0.0)	[0.0, 0.0]
offering any milk	16	(94.1)	16	(100.0)	(5.9)	[–5.2, 17.0]
offering any sugar-sweetened beverages	17	(100.0)	16	(100.0)	(0.0)	[0.0, 0.0]
offering any alcohol	9	(52.9)	7	(43.8)	(–9.2)	[–33.7, 15.3]
Restaurants	15	(13.9)	13	(12.1)	(–1.7)	[–5.3, 1.9]
offering any drink ^b	15	(100.0)	13	(100.0)	(0.0)	[0.0, 0.0]
offering any water	15	(100.0)	13	(100.0)	(0.0)	[0.0, 0.0]
offering any milk ^c	0	(0.0)	5	(38.5)	(38.5)	[12.2, 64.7]
offering any sugar-sweetened beverages	15	(100.0)	13	(100.0)	(0.0)	[0.0, 0.0]
offering any alcohol	0	(0.0)	0	(0.0)	(0.0)	[0.0, 0.0]
OSBs	71	(65.7)	71	(66.4)	(0.6)	[–5.5, 6.7]
offering any drink ^b	7	(9.9)	10	(14.1)	(4.2)	[–1.8, 10.2]
offering any water	6	(8.5)	8	(11.3)	(2.8)	[–3.7, 9.3]
offering any milk	4	(5.6)	5	(7.0)	(1.4)	[–1.3, 4.1]
offering any sugar-sweetened beverages	6	(8.5)	8	(11.3)	(2.8)	[–2.6, 8.3]
offering any alcohol	3	(4.2)	3	(4.2)	(0.0)	[–0.7, 0.7]
Street vendors	5	(4.6)	7	(6.5)	(1.9)	[–3.6, 7.4]
offering any drink ^b	1	(20.0)	2	(28.6)	(8.6)	[–41.5, 58.6]
offering any water	1	(20.0)	2	(28.6)	(8.6)	[–40.5, 57.6]
offering any milk	0	(0.0)	1	(14.3)	(14.3)	[–11.6, 40.2]
offering any sugar-sweetened beverages	1	(20.0)	1	(14.3)	(–5.7)	[–50.8, 39.4]
offering any alcohol	0	(0.0)	0	(0.0)	(0.0)	[0.0, 0.0]

OSBs = other storefront businesses not primarily focused on food/drink selling like laundromats, hardware stores, and barber shops (please see footnotes to Appendix – Table A1 for more specific examples).

^a Businesses in this table are restricted to those open at the time of assessments; only open business allowed for exact determination of drink offerings.

^b Other drinks assessed included those in two additional categories—“diet drinks” and “100% juices.” These drink categories were considered neither “healthful” nor “less-healthful” given scientific debate. Values for these categories are available from the authors upon request.

^c The five restaurants that started offering milk between 2016 and 2017 were the following: two outlets of a national sandwich chain, one outlet of a national donut chain, one outlet of a regional Caribbean fast-food chain, and one independent juice bar/café.

^d Column percentage; denominators for column percentages are the n values in the preceding table row having the lesser degree of indentation.

and one stopped offering healthful items that previously had. Shifts to *any* less-healthful offerings exceeded (by one business) shifts to *any* healthful offerings; shifts to *any* healthful offerings were due entirely to businesses initiating sales of bottled water. Overall, the absolute number of businesses offering *any* less-healthful items exceeded the number offering *any* healthful items in both years.

Appendix – Table A1 shows that among existing businesses, the only ones shifting between *any* healthful and *any* less-healthful offerings were OSBs. OSBs accounted for 15.0% of businesses offering healthful items in 2016 and 21.4% in 2017; they accounted for 25.0% of businesses offering less-healthful items in 2016 and 32.6% in 2017 (calculated from table values).

Table 4 shows changes in food/drink availability at the street-segment level. Food/drink was available on one additional street segment in 2017 (n = 17) than in 2016 (n = 16). One street segment stopped offering food/drink when its only business offering food (a check-cashing outlet) removed its candy dispenser. Two additional street segments newly had water available; on one of those segments, sugary drinks and frozen confections also newly became available.

Table 5 shows that nuts was the only category of food available on more streets in 2017 than 2016. Alcohol remained equally available in both years; all other beverages became more available. Given small sample sizes, confidence intervals for all street-level changes were wide.

6. Discussion

On a sample of urban streets over a 10-month period, the current

study assessed change in food/drink availability. There was noteworthy change at the level of individual businesses: While some businesses shut down or stopped offering food/drink, more businesses newly opened or began food/drink sales. Whereas net differences might be quite modest for a given person in the study area, food/drink became available from a greater number of businesses on a greater number of streets overall. Whereas restaurants and what are commonly thought of as “food stores” became less numerous, the number of food/drink-offering OSBs and street vendors grew. Whereas there were increasing percentages of businesses offering healthful items, sources of less-healthful items were already more numerous and remained so. Additionally, there were increasing percentages of businesses offering any—and *only*—less-healthful options. Small numbers, select sampling, and other caveats notwithstanding, study findings have important implications both for food-environment research and community health.

For community health, one implication is that food/drink availability may be increasing. In the current study, nuts (a healthful food) and milk (a healthful drink) were available from more businesses in 2017 than 2016. Increasing nut availability might have mirrored increasing consumer demand, given each of the following occurring around 2016: emerging evidence of health benefits (Aune et al., 2016); policy recommendations (Mozaffarian, 2016); and favorable press (Bakalar, 2016; Go, 2016). Increasing milk availability might likewise have been related to supportive research (Lu et al., 2016; Thorning et al., 2016), recommendations (Mozaffarian, 2016), and media attention (Dillner, 2016; Should, 2016), as well as to pledges by industry to improve healthfulness of offerings (Toy, 2017).

Table 3
Business-level changes in “yes/no” food/drink availability by healthfulness—from 2016 to 2017 on 119 street segments in the Bronx, NY.

Characteristics of businesses	Businesses ^c			
	2016 n ^d	2016 (%)	2017 n ^d	2017 (%)
Total number of businesses offering any food/drink	45	(1 0 0)	49	(1 0 0)
↓Shutting down between 2016 and 2017	6 ^e	(13.3)		
↓Remaining in operation but no longer offering any food/drink in 2017	3 ^e	(6.7)		
-Remaining in operation and still offering any food/drink in 2017	36	(80.0)	36	(73.5)
↑Shift from not offering any food/drink in 2016 to offering any food/drink in 2017			3 ^e	(6.1)
↑Newly opening since 2016 and offering any food/drink in 2017			10 ^e	(20.4)
Total number of businesses offering any healthful items^a	40	(1 0 0)	42	(1 0 0)
↓Shutting down between 2016 and 2017	6 ^e	(15.0)		
↓Remaining in operation but no longer offering any food/drink in 2017	1 ^e	(2.5)		
↓Remaining in operation and still offering any food/drink but no longer offering any healthful items in 2017	1 ^e	(2.5)		
-Remaining in operation and still offering any healthful items in 2017	32	(80.0)	32	(76.2)
↑Shift from offering only less-healthful items, in 2016 to offering any healthful items in 2017			1 ^e	(2.4)
↑Shift from not offering any food/drink in 2016 to offering any healthful items in 2017			1 ^e	(2.4)
↑Newly opening since 2016 and offering any healthful items in 2017			8 ^e	(19.0)
Total number of businesses offering any less-healthful items^b	44	(1 0 0)	46	(1 0 0)
↓Shutting down between 2016 and 2017	5 ^e	(11.4)		
↓Remaining in operation but no longer offering any food/drink in 2017	3 ^e	(6.8)		
↓Remaining in operation and still offering any food/drink but no longer offering any less-healthful items in 2017	0	(0.0)		
-Remaining in operation and still offering any less-healthful items in 2017	36	(81.8)	36	(78.3)
↑Shift from offering only healthful items, in 2016 to offering any less-healthful items in 2017			0	(0.0)
↑Shift from not offering any food/drink in 2016 to offering any less-healthful items in 2017			3 ^e	(6.5)
↑Newly opening since 2016 and offering any less-healthful items in 2017			7 ^e	(15.2)

↓Decreased, -Stable, ↑Increased.

^a ‘any healthful items = any healthful food (fruits, vegetables, whole grains, nuts) or healthful drink (water, milk), regardless of other food/drink offerings.

^b ‘any less-healthful items = any less-healthful food (‘refined sweets,’ ‘salty/fatty fare’) or less-healthful drink (‘sugar-sweetened beverages,’ alcohol), regardless of other food/drink offerings.

^c Businesses included food stores, restaurants, OSBs (other storefront businesses), and street vendors. Please see [Appendix – Table A1](#) for breakdown.

^d There were 108 businesses overall in 2016 and 107 businesses overall in 2017.

^e For details on exact shifts between specific business and specific food/drink offerings, please see [Appendix – Table A1](#).

Nonetheless, while having healthier options may be a good thing, increasing cues to drive overconsumption are not (Cohen, 2008; Cohen et al., 2014). In the current study, not only did more businesses offer refined sweets in 2017 than in 2016, fewer offered fruits or vegetables; the result was an increase in businesses offering *only* less-healthful

items. Although findings could be asserted with $\geq 95\%$ confidence, the possibility of unhealthy cues increasing is not reassuring—especially if unopposed by any cues for healthful options.

Considering cues for healthful and less-healthful options together, nearly half of all businesses in 2017 (45.8%) offered at least some kind

Table 4
Street-segment-level change in “yes/no” food/drink availability by healthfulness—from 2016 to 2017 on 119 street segments in the Bronx, NY.

Characteristics of street segments	Street Segments			
	2016 n ^d	2016 (%)	2017 n ^d	2017 (%)
Total number of street segments offering any food/drink	16	(1 0 0)	17	(1 0 0)
↓No longer offering any food/drink in 2017 ^a	1 ^e	(6.3)		
-Continuing to offer any food/drink in 2017 ^b	15	(93.8)	15	(88.2)
↑Shift from not offering any food/drink in 2016 to offering any food/drink in 2017 ^c			2 ^f	(11.8)
Total number of street segments offering any healthful items^d	14	(1 0 0)	16	(1 0 0)
↓No longer offering any healthful items in 2017 ^a	0	(0.0)		
-Continuing to offer any healthful items in 2017 ^b	14	(1 0 0)	14	(87.5)
↑Shift from not offering any healthful items in 2016 to offering any healthful items in 2017 ^c			2 ^f	(12.5)
Total number of street segments offering any less-healthful items^e	16	(1 0 0)	16	(1 0 0)
↓No longer offering any less-healthful items in 2017 ^a	1 ^e	(6.3)		
-Continuing to offer any less-healthful items in 2017 ^b	15	(93.8)	15	(93.8)
↑Shift from not offering any less-healthful items in 2016 to offering any less-healthful items in 2017 ^c			1 ^f	(6.3)

↓Decreased, -Stable, ↑Increased.

^a “No longer offering” could be due to business(es) closing and/or business(es) ceasing sales on a given street segment.

^b “Continuing to offer” could be due to no change among businesses, but it could also be due to no net change (i.e., offsets among businesses opening, closing, starting sales, and/or stopping sales at the street-segment level).

^c “Shift from not offering to offering” could be due to business(es) opening and/or business(es) initiating sales on a given street segment.

^d There were 119 street segments in 2016 and the same 119 street segments in 2017.

^e The one street segment that stopped offering food/drink was due to a check-cashing outlet that removed its candy dispenser between 2016 and 2017; neither of the other two businesses on that street (a shoe repair shop that closed between 2016 and 2017 and a gym that was open 2016 and 2017) offered food/drink in either year.

^f The two street segments newly offering food/drink in 2017 were due to street vendors: one street segment had a new ice cream truck selling water, sugary drinks, and frozen confections; the other street segment had a new vendor offering only bottled water.

Table 5
Street-segment-level change in “yes/no” food/drink availability by food category and by drink category—2016 versus 2017 on 119 street segments in the Bronx, NY.

Characteristics of street segments	2016 n ^b	(%)	2017 n ^b	(%)	Difference 2017–2016 (%age points)	[95% CI]
Street segments having ≥ 1 open business ^a	18	(100)	18	(100)	–	–
Food items only						
offering any food	16	(88.9)	16	(88.9)	(0.0)	[-21.0, 21.0]
offering any fruits or vegetables	14	(77.8)	14	(77.8)	(0.0)	[-5.6, 5.6]
offering any whole grains	11	(61.1)	11	(61.1)	(0.0)	[-27.3, 27.3]
offering any nuts	10	(55.6)	14	(77.8)	(22.2)	[-2.5, 47.0]
offering any refined sweets	16	(88.9)	16	(88.9)	(0.0)	[-21.0, 21.0]
offering any salty/fatty fare	14	(77.8)	14	(77.8)	(0.0)	[-5.6, 5.6]
Drink items only						
offering any drink	14	(77.8)	16	(88.9)	(11.1)	[-9.0, 31.2]
offering any water	14	(77.8)	16	(88.9)	(11.1)	[-9.0, 31.2]
offering any milk	13	(72.2)	15	(83.3)	(11.1)	[-9.0, 31.2]
offering any sugar-sweetened beverages	14	(77.8)	15	(83.3)	(5.6)	[-10.6, 21.7]
offering any alcohol	8	(44.4)	8	(44.4)	(0.0)	[-21.0, 21.0]

^a In 2016, there were three street segment having only businesses that were closed. In 2017, there were also three street segments having only businesses that were closed. Two of the street segments having only businesses that were closed were the same in 2016 and 2017.

^b There were 119 street segments in 2016 and the same 119 street segments in 2017.

of food—at least some kind of “cue.” This value was an increase from the already substantial 2016 value of 41.7%. In an earlier study, depending on neighborhood 41.7–46.6% of storefront businesses offered food (Lucan et al., 2018c). In another study, when drinks were also considered, some food or drink could be found from 50.7% of storefront businesses (Lucan et al., 2018b). In that study, storefront businesses made food/drink available from 14.7% of all street segments (Lucan et al., 2018b). In the current study, which also included street vendors, food/drink availability increased from 13.4% to 14.3% of street segments, 2016 to 2017. Additionally, given distributions of businesses on streets, some food/drink could be found on almost any street segment having any kind of business—a finding consistent with prior research (Lucan et al., 2020).

On city streets over time, the categories of businesses offering food/drink may be shifting. Over the 10-month period of the current study, both restaurants and food stores were found on proportionally fewer street segments; both OSBs and street vendors were found on proportionally more. In prior studies, OSBs have accounted for 23.9%–34.4% of storefront food/drink sources (Lucan et al., 2018a,b,c; Lucan et al., 2013a). Street vendors have accounted for 7.6–8.1% of all food/drink sources (Lucan et al., 2020). OSBs and street vendors together have represented 22.8–37.5% of businesses offering any healthful food/drink and 71.4–96.5% of businesses offering only less-healthful options (Lucan et al., 2020).

The increasing number (and proportion) of business offering food/drink—particularly less-healthful varieties—is certainly a concern for community health. It is also a concern for research. Indeed, the vast majority of food-environment research ignores two increasingly prominent food/drink sources—OSBs and street vendors (Caspi et al., 2012; Cobb et al., 2015; Malambo et al., 2016; McKinnon et al., 2009; Lytle and Sokol, 2017; Lucan, 2015). As a result, determinations of “food deserts” or “food swamps” might be completely—and increasingly—mischaracterized (Lucan et al., 2020). With multi-year discrepancies between when food-environment “exposures” are measured and when study designs specify they should be (Appendix – Box 1 for details), substantive food/drink “exposure” shifts over just a few months could result in important misclassification error. If months-long shifts are random across business categories—and random across food/drink categories—the result would be “noise,” challenging detection of useful “signal” to cause false-negative results. However, if shifts are systematic within categories, the result could be bias, resulting in either

false-negative or false-positive associations. Certainly, the existing literature demonstrates many counterintuitive findings in both positive and negative directions; it is possible misclassifications due to shifting “exposures” could be a contributor (Cobb et al., 2015; Malambo et al., 2016).

The current study has many strengths. First, it assessed business- and street-segment-level changes (related to businesses opening, shutting down, starting to offer food/drink, or ceasing to do so) and area-level changes (related to overall counts of businesses present at different times). The longitudinal matched-pair design—from both prospective and retrospective vantage points—improved upon serial cross-sections used in prior work. Findings about individual businesses (specific food/drink sellers), the street segments on which they were located (given “blocks”), and the broader sample overall (area as a whole) are all relevant for food environment considerations. Second, the current study assessed a full range of storefront and non-storefront businesses. Third, data collection considered not just where businesses were (“community food environment”) but what businesses sold (“consumer food environment”); it also avoided common, problematic assumptions about business categories (e.g., supermarkets = “healthy”, fast food = “unhealthy”) as experts discuss (Caspi et al., 2012; Lucan, 2015; Rose et al., 2010). Fourth, analyses separately considered several categories of food, several categories of drink, and the combination of food and drink. Fifth, analyses separately considered healthful items, less-healthful items, and the combination of the two. Finally, the 10-month study interval allowed for finer estimation of the pace of food-environment change than in prior studies.

Limitations of the current study include its modestly sized convenience sample having limited geographic representation. Nonetheless, the presence of food/drink sellers by street segment (13.4% in 2016, 14.3% in 2017) closely matched the presence found in a much larger, geographically more-distributed sample—all 1253 street segments in 32 Bronx census tracts, where 14.7% had food/drink sellers (Lucan et al., 2018b). Findings were also consistent with those reported in several other studies. For example, if rates of change were steady, data from four California cities (from 1981/1982 to 1989/1990) suggest a 10-month increase in storefront food/drink sources of 5.8% (Wang et al., 2008); data from four Massachusetts towns (from 1971–1975 to 2005–2008) suggest a 10-month increase of about 1.2% (James et al., 2017); and data from Brooklyn (from 2007 to 2011) suggests a 10-month increase of about of 4.5% (Filomena et al., 2013).

Data from other parts of the Bronx (from 2010 to 2015), suggest a 10-month increase in storefront food/drink sources of 4.9% (Lucan et al., 2018a). The current study showed a 10-month increase in storefronts of 2.3%. Thus, findings may approximate—and perhaps even underestimate—storefront change observed elsewhere.

Distinct from prior work on food-environment change, the current study expressly considered non-storefront businesses—e.g., street vendors. As prior work shows, street vendors can be variably present by both weather and season (Lucan et al., 2014; Lucan et al., 2013b). In the current study, both weather and season were similar on assessment days in both years (Appendix – Table A2); street vendors might have been similarly expected at both observation times (Lucan et al., 2013b). Another type of non-storefront business, the farmers' market, is also variably present by season (Lucan, 2019). As with street vendors, most farmers' markets operate in both August and October (Lucan et al., 2015). However, none are known to operate in the study area (Lucan et al., 2015). As expected, none were found at either observation time. If any street vendors or farmers' markets were missed in either year, the effect on overall food-environment change could have been in either direction—i.e., to augment found changes or to somewhat diminish them. However, any missed vendors or markets would necessarily make the currently reported values of food/drink offering, at either or both observation times, underestimate.

Similarly, some food/drink availability could have been missed due to businesses being closed at assessment times (generally weekdays between 10am and 4pm). Only open businesses allowed for exact determination of food/drink offerings. Businesses closed at times of assessment (e.g., due to worker vacations, renovations, nighttime-only hours of operation) included three restaurants and 18 OSBs in 2016 and five restaurants and 15 OSBs in 2017. Closed businesses could have affected change in overall food/drink offering in either direction but would have necessarily made reported values for availability underestimate.

Another limitation of the current study was a focus only on select “healthful” and “less-healthy” items, using “yes/no” availability; there were no determinations of broader offerings, relative inventories, or consumer purchases. As a result, we can only conclude about increasing numbers of places where food/drink was available—not increasing amounts (or proportions) of specific foods/drinks within either given outlets or shoppers' baskets. Nonetheless, there is evidence that OSBs increasingly offer volume and variety (Tree and Strong, 2017). Also, for street vendors, increased sales can mean decreased sales from storefronts, like discount stores and supercenters (Gary-Webb et al., 2018).

7. Conclusion

Urban food environments can extend well beyond restaurants and so-called “food stores.” In the current study, OSBs and street vendors

Appendix

Box 1: Concerns regarding 124 studies (published 2002–2017) due to food-environment change.^a

Concerns:

- For cross-sectional studies (84% of the total), study design specifies concurrent “exposure” and “outcome” assessment; multi-year discrepancies between “exposure” and “outcome” assessments can lead to error if food environments change over time.
- For 57 studies (46% of the total), “exposure” times definitively differed from “outcome” times by more than a single year; in 39 cases (31% of all studies) “outcome” assessment *preceded* “exposure” assessment by more than a single year.

Caveats:

- Exact study design (e.g., cross-sectional, serial cross-sectional, longitudinal) was not always clear from each paper's methods section
- Years of actual assessments for food-environment “exposures” and for diet and/or disease “outcomes” were not always clear; dates were indeterminate for 18 studies (15% of all studies).

^aTable of 124 studies from systematic reviews—and from co-authors' personal collections—available from the authors upon request.

represented substantial and increasing proportions of food/drink-offering businesses; their presence and potential should be recognized in future research. Considering all businesses together, in the current study more businesses newly opened or started selling food/drink over a 10-month period than shut down or stopped offering food/drink over the same time. Healthful items became available from a greater number of sellers, but so did less-healthy items, which more businesses already offered. By not appreciating the full extent of change in food/drink offering, the implications for food-environment research could be mischaracterized “exposures,” false associations, and invalid conclusions. The implications for community health could be misidentified intervention targets, wasted resources, and missed opportunities to address true issues related to both healthful and less-healthy food access. Additionally, if study findings are generalizable to other settings (as prior research suggests they may be), greater numbers of businesses engaged in selling food/drink may normalize ubiquitous availability; the result could be conditions for increased (perhaps increasingly un-healthy) consumption.

Disclosure

SCL has served on the Scientific and Nutritional Advisory Board of Epicure (a Canadian food-product and cookware company). This study did not involve human subjects; it was part of a broader human-subjects research project (K23HD079606) approved by the Albert Einstein College of Medicine IRB under federal regulations 45 CFR 46.110 and 21 CFR 56.110. For data collection and management, the study used REDCap electronic data capture tools hosted through the Harold and Muriel Block Institute for Clinical and Translational Research at Einstein and Montefiore under grant UL1 TR001073. This work was also partially supported by the New York Regional Center for Diabetes Translation Research under grant P30 DK111022.

CRedit authorship contribution statement

Andrew R. Maroko: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Visualization, Writing - review & editing.

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Table A1
Business-level changes in “yes/no” food/drink availability by healthfulness and by business category—from 2016 to 2017 on 119 street segments in the Bronx, NY.

Characteristics of businesses	Food stores						Restaurants						OSBs						Street Vendors					
	2016		2017		2016		2017		2016		2017		2016		2017		2016		2017					
	n ^b	(%)	n ^b	(%)	n ^b	(%)	n ^b	(%)	n ^b	(%)	n ^b	(%)	n ^b	(%)	n ^b	(%)	n ^b	(%)	n ^b	(%)				
Total offering any food/drink	17	(100)	16	(100)	15	(100)	13	(100)	11	(100)	15	(100)	2	(100)	5	(100)								
‡Shutting down between 2016 and 2017	1 ^c	(5.9)	3 ^d	(20.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	2 ^k	(100)	0	(0.0)								
‡Remaining in operation but no longer offering any food/drink in 2017	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	3 ^f	(27.3)	0	(0.0)	0	(0.0)	0	(0.0)								
-Remaining in operation and still offering any food/drink in 2017	16	(94.1)	16	(100)	12	(80.0)	12	(92.3)	8	(72.7)	8	(53.3)	0	(0.0)	0	(0.0)								
‡Shift from not offering any food/drink in 2016 to offering any food/drink in 2017	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	3 ^h	(20.0)	0	(0.0)	0	(0.0)								
‡Newly opening since 2016 and offering any food/drink in 2017	0	(0.0)	0	(0.0)	0	(0.0)	1 ^e	(7.7)	0	(0.0)	4 ⁱ	(26.7)	0	(0.0)	5 ^j	(100)								
Total offering any healthful items^a	17	(100)	16	(100)	15	(100)	13	(100)	6	(100)	9	(100)	2	(100)	4	(100)								
‡Shutting down between 2016 and 2017	1 ^c	(5.9)	3 ^d	(20.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	2 ^k	(100)	0	(0.0)								
‡Remaining in operation but no longer offering any food/drink in 2017	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	1 ^f	(16.7)	0	(0.0)	0	(0.0)	0	(0.0)								
-Remaining in operation and still offering any healthful items in 2017	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	1 ^g	(16.7)	0	(0.0)	0	(0.0)	0	(0.0)								
‡Shift from offering only less-healthful items, in 2016 to offering any healthful items in 2017	16	(94.1)	16	(100)	12	(80.0)	12	(92.3)	4	(66.7)	4	(44.4)	0	(0.0)	0	(0.0)								
‡Shift from not offering any food/drink in 2016 to offering any healthful items in 2017	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	1 ^j	(11.1)	0	(0.0)	0	(0.0)								
‡Newly opening since 2016 and offering any healthful items in 2017	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	1 ^h	(11.1)	0	(0.0)	0	(0.0)								
Total offering any less-healthful items^a	17	(100)	16	(100)	15	(100)	13	(100)	11	(100)	15	(100)	1	(100)	2	(100)								
‡Shutting down between 2016 and 2017	1 ^c	(5.9)	3 ^d	(20.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	1 ^k	(100)	0	(0.0)								
‡Remaining in operation but no longer offering any food/drink in 2017	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	3 ^f	(27.3)	0	(0.0)	0	(0.0)	0	(0.0)								
-Remaining in operation and still offering any less-healthful items in 2017	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)								
‡Shift from offering only healthful items, in 2016 to offering any less-healthful items in 2017	16	(94.1)	16	(100)	12	(80.0)	12	(92.3)	8	(72.7)	8	(53.3)	0	(0.0)	0	(0.0)								
‡Shift from not offering any food/drink in 2016 to offering any less-healthful items in 2017	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)								
‡Newly opening since 2016 and offering any less-healthful items in 2017	0	(0.0)	0	(0.0)	0	(0.0)	1 ^e	(7.7)	0	(0.0)	3 ^h	(20.0)	0	(0.0)	2	(100)								

‡Decreased, -Stable, †Increased; OSBs = Other storefront businesses.

^a Please see footnotes to Table 3 for definition.

^b There were 108 businesses overall in 2016 and 107 businesses overall in 2017

^c The “food store” that closed was a fish market that sold both healthful items (e.g., mixed vegetables) and less-healthful items (e.g., soda).

^d The three restaurants that closed were a confectionary bakery, pizzeria, and Chinese restaurant; each had offered both healthful and less-healthful items.

^e The restaurant that opened was a seafood restaurant, offering both healthful and less-healthful items.

^f OSBs that stopped offering food/drink were a furniture store (that had offered bottled water and sugary coffee drinks in 2016), a hair salon (that had offered candy bars in 2016), and a check cashing outlet (that had had a candy dispenser in 2016).

^g The one OSB that continued to offer food/drink but stopped offering any healthful items was a laundromat that stopped offering bottled water (while continuing to offer sodas, juice drinks, salty snacks, and candy). OSBs shifting from not offering to offering food/drink were a laundromat (introducing lollipops), a hair salon (introducing candy dispensers), and a barber shop (introducing dispensers of candy, salty snacks, sugar-sweetened beverages, juices, and water).

^h OSBs newly opening and offering food/drink included a dollar store (offering many varieties of healthful and less-healthful items), a gym (selling water, energy drinks, and sugary sports bars), a barber shop (having both a pistachio dispenser and a candy machine), and a pharmacy (offering only less-healthful items like candy, cookies, and salty snacks).

ⁱ The one OSB shifting from food/drink offering excluding healthful items to food/drink offering including healthful items was a dollar store selling candy and chips in both years and selling only bottled water in 2017.

^j Street vendors that were no longer present in 2017 were an “NYC Green Cart” (government-permitted produce vendor selling only whole, fresh, unprocessed fruits and vegetables) and Halal-food cart (selling healthful and less-healthful items).

^k Street vendors that newly opened and offered food/drink included the following: two produce stands (selling only fruits and vegetables); a vendor selling only bottled water; an ice-cream truck (selling frozen confections, sugary drinks, and water); and flavored-ice cart (selling only frozen confections).

Table A2
Weather Conditions at the Times of Data Collection in 2016 and 2017 on 119 street segments in the Bronx, NY.

Date of data collection in 2016	General Weather	Daytime High (°F)	Daytime Low (°F)
October 11	Sunny	63	57
October 12	Sunny	64	61
October 13	Partly sunny	66	63
October 15	Sunny	64	57
Date of data collection in 2017	General Weather	Daytime High (°F)	Daytime Low (°F)
August 2	Sunny→ light rain	79	70
August 3	Sunny	86	81
August 8	Partly sunny	77	72
August 9	Sunny	82	79

<https://www.timeanddate.com/weather/@5110253/historic?month=10&year=2016>.

<https://www.timeanddate.com/weather/@5110253/historic?month=8&year=2017>.

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