

# Change in an Urban Food Environment: Storefront Sources of Food/Drink Increasing Over Time and Not Limited to Food Stores and Restaurants



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## ABSTRACT

**Background** Local food environments include *food stores* (eg, supermarkets, grocery stores, bakeries) and restaurants. However, the extent to which other storefront businesses offer food/drink is not well described, nor is the extent to which food/drink availability through a full range of storefront businesses might change over time.

**Objectives** This study aimed to assess food/drink availability from a full range of storefront businesses and the change over time and to consider implications for food-environment research.

**Design** Investigators compared direct observations from 2010 and 2015.

**Participants/setting** Included were all storefront businesses offering foods/drinks on 153 street segments in the Bronx, NY.

**Main outcome measures** The main outcome was change between 2010 and 2015 as determined by matches between businesses. Matches could be *strict* (businesses with the same name on the same street segment in both years) or *lenient* (similar businesses on the same street segment in both years). Investigators categorized businesses as general grocers, specialty food stores, restaurants, or *other storefront businesses* (eg, barber shops/beauty salons, clothing outlets, hardware stores, laundromats, and newsstands).

**Statistical analyses performed** Investigators quantified change, specifically calculating how often businesses in 2015 were present in 2010 and vice versa.

**Results** Strict matches for businesses in 2015 present in 2010 ranged from 29% to 52%, depending on business category; lenient matches ranged from 43% to 72%. Strict matches for businesses in 2010 present in 2015 ranged from 34% to 63%; lenient matches ranged from 72% to 83%. In 2015 compared with 2010, on 22% more of the sampled street segments, 30% more businesses were offering food/drink: 66 vs 46 general grocers, 22 vs 19 specialty food stores, 99 vs 99 restaurants, 98 vs 56 other storefront businesses.

**Conclusions** Over 5 years, an urban food environment changed substantially, even by lenient standards, particularly among “other storefront businesses” and in the direction of markedly greater food availability (more businesses offering food on more streets). Failure to consider a full range of food/drink sources and change in food/drink sources could result in erroneous food-environment conclusions.

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OVER ABOUT THE LAST 2 DECADES, AN INCREASING amount of research has linked local food environments to dietary intake<sup>1-3</sup> and downstream diet-related health outcomes.<sup>4-6</sup> Just as diets and health can change over time, so too can the local food environments that might influence them.

A study of local food environments in four mid-sized California cities showed progressive increases in the number and density of neighborhood food outlets across four waves of observation over 10 years (1981 to 1990).<sup>7</sup> Another study in

four towns in Massachusetts similarly showed mostly progressive increases in proximity to and density of food outlets across eight waves of observation spanning more than 30 years (1971 to 2008).<sup>8</sup> In a nationally representative cohort, a majority of children lived in neighborhoods where the number of food outlets changed over 3 years (2004 to 2007), sometimes in a direction of increasing quantity and sometimes in a direction of decreasing quantity.<sup>9</sup>

Although these studies provide some estimate of how local food environments can change, they focus only narrowly on a

limited variety of food/drink sources, that is, *food stores* (eg, supermarkets, grocery stores, convenience stores, bakeries) and restaurants (various full-service and limited-service eateries including fast-food outlets, pizzerias, and doughnut shops).<sup>7-9</sup> In reality, food/drink sources may include a wide range of other storefront businesses, such as gas marts, pharmacies, and dollar stores,<sup>10-14</sup> and also retail outlets less likely to be considered food/drink sources (eg, hardware stores, automobile shops, furniture stores, apparel outlets, and beauty salons).<sup>15-19</sup> Ignoring such other businesses may provide an incomplete picture of how extensive food environments are and how they may change when considered broadly.

For the present study, we conducted a broad assessment of all storefront businesses that might contribute to an urban food environment at two points in time. Having completed an initial assessment in the Bronx, NY, 5 years earlier,<sup>17</sup> and subsequent assessments in surrounding neighborhoods since then,<sup>18-24</sup> we had observed some changes on Bronx streets that seemed to suggest increasing food/drink availability (eg, new storefronts opening and existing storefronts starting to offer food/drink items). We hypothesized that food/drink would be available from more places on more streets at the time of our subsequent assessment than at the time of our initial assessment. We sought to describe the range of storefront businesses offering food/drink and any changes that took place over 5 years. Our aim was also to consider potential implications for food-environment research, specifically for studies that do not consider a full range of possible storefront food/drink sources or change over time.

## MATERIALS AND METHODS

As described previously,<sup>17</sup> members of our research team assessed a random sample of street segments (regions along streets from one intersection to the next) in the Bronx, NY, during the summer of 2010. The original sample included 155 street segments in commercial, residential, and mixed-use areas. The 2010 assessment was considered exempt by the Albert Einstein College of Medicine Institutional Review Board.

The follow-up sample, observed in the summer of 2015, contained the same 155 street segments. However, owing to an error in recorded east vs west distinction for two of the included avenues, the total set of street segments observed in both years was 153 (see the [Figure](#)). The 2015 assessment was approved by the Albert Einstein College of Medicine Institutional Review Board as part of a broader study.

For data collection and management, the original assessment in 2010 used paper forms and Microsoft Excel for Mac 2008.<sup>25</sup> Re-assessment in 2015 used smartphone data entry through REDCap.<sup>26</sup> REDCap is a secure, web-based application, providing an interface for validated data entry, audit trails for tracking data manipulation, and automated export procedures for downloads to statistical packages.<sup>27</sup>

In both assessment years, investigators worked in pairs, recording the names, addresses, and global positioning system (GPS) coordinates of all storefront businesses on street segments. As a reliability check in 2010, two pairs of investigators separately assessed a sample of the same 30 street segments to ensure consistency in data collection. As a reliability check in 2015, each investigator of a single pair likewise separately assessed a sample of 30 street segments. In both years, there was essentially perfect agreement in data

## RESEARCH SNAPSHOT

**Research Questions:** What are the storefront sources of food/drink in an urban environment? Do they change over time? What are the implications for food-environment research?

**Key Findings:** Storefront sources of food/drink include *other businesses* (eg, barber shops/beauty salons, clothing outlets, hardware stores, laundromats, newsstands) often ignored in food-environment research. Over 5 years, 30% more storefronts were offering food/drink on 22% more of the sampled streets, with “other storefront businesses” increasing from 26% to 34% of the total of food/drink sources (comparable in number to restaurants, greater in number than *food stores*). Findings challenge research that fails to consider a full range of storefront food/drink sources or change over time.

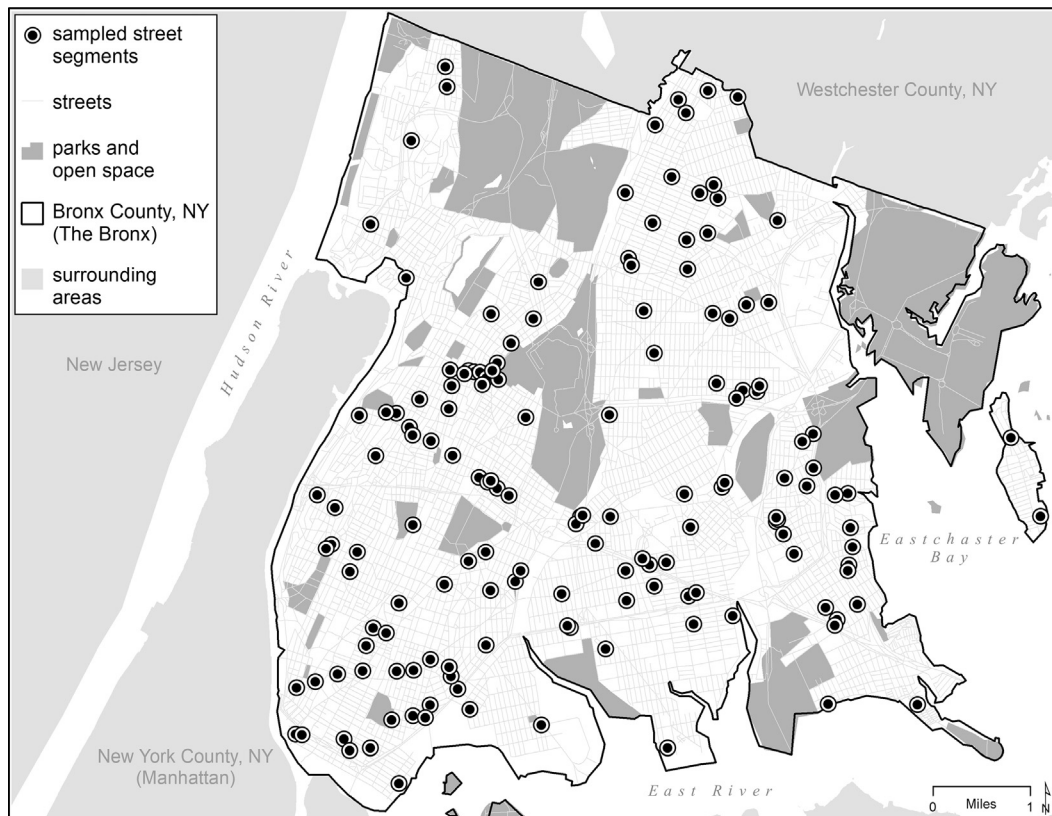
collected between investigators. The only differences were at inconsequential decimal places for GPS coordinates (due to inherent measurement imprecision) and in the completeness of recorded business names (eg, *Yolanda’s Italian vs Yolanda’s Italian Pizzeria & Restaurant*).

Investigators applied the scheme used in the original 2010 assessment<sup>17</sup> to categorize businesses observed in both years. Four business categories included *general grocers* (eg, supermarkets, grocery stores, corner stores/bodegas), *specialty food stores* (eg, bakeries, butcher shops, produce markets, fish markets), *restaurants* (including take-away and table-service establishments), and *other storefront businesses* for which food/drink sales were not the primary focus (eg, department stores, variety stores, pharmacies, gas stations, newsstands, hardware stores, electronics shops, clothing stores, salons).

For every identified storefront business, investigators determined whether any foods/drinks were for sale based on signage, menus/menu boards, product displays, and inquires of staff. In both 2010 and 2015, assessments included all storefront businesses. However, because of the more limited scope of the project in 2010,<sup>17</sup> only businesses offering food/drink items were included in the recorded data that year.

Data analyses compared observations from 2010 with observations from 2015 and assessed for change on sampled street segments between years. Change between years was determined by matching businesses at the street-segment level. Investigators defined matches of two levels of stringency. *Strict matches* were between businesses with the exact same name or a consistent name (eg, *Webster Drugs vs Webster Pharmacy, Kasike Restaurant vs Kasike Mofongo Bar & Grill, Pruzzo’s Supermarket vs Pruzzo’s Supermarket*) on the same street segment. *Lenient matches* were between businesses thought to be similar (eg, *High Life Deli and Grocery vs Hygrade Food Market, The Best Roma Pizzeria vs Papa Lenny Restaurant, Key Food vs Bravo Supermarket, and Popeye’s vs Subway*) on the same street segment.

Lenient matches were liberal by design to allow for generous best-case scenarios in determining food-environment stability. For instance, a fried-chicken outlet and a submarine (hero/hog) sandwich shop may represent two different fast-food franchises with qualitatively different food and drink



**Figure.** The 153 street segments sampled from across the Bronx to assess change in food/drink availability over time. Markers for sampled street segments may appear fewer than 153 as a result of overlap of symbols at this scale. Commercially dense areas contained several sampled street segments.

offerings. However, to the extent that any sources of fast food contribute similarly to food-environment exposures, these two establishments were considered equivalent for lenient matching. Considering different fast-food franchises as equivalent for matching purposes is consistent with previous research.<sup>17,28</sup>

Strict matches were more rigorous than lenient matches but not completely exact. Specifically, strict criteria required neither perfect address matching nor perfect GPS matching for businesses. Strict matches required only that the same business be on the same street segment in both years. Thus, if a donut shop was present in 2010, closed in 2011, and then reopened 2 years later at a new location on the same street segment, the result would still be a strict match (comparing food sources in 2010 with those in 2015). Such tolerance, even for strict matches, again allowed for generous best-case scenarios in determining food-environment stability.

Based on strict and lenient matches, investigators used Stata/SE version 12.1<sup>29</sup> to calculate how often businesses on a street segment in 2015 were previously present on the same street segment in 2010 and how often businesses on a street segment in 2010 were still present on the same street segment in 2015. Investigators also used Stata to calculate frequencies, proportions, and confidence intervals, analyzing the sample as a whole and by the four business categories.

## RESULTS

In 2010, 220 storefront businesses were selling foods/drinks on 50 of the 153 assessed street segments: 46 general grocers, 19

specialty food stores, 99 restaurants, and 56 other storefront businesses. In 2015, 285 storefront businesses were selling foods/drinks on 61 of the same 153 street segments: 66 general grocers, 22 specialty food stores, 99 restaurants, and 98 other storefront businesses. These values, as well as values for forward and retrospective agreement by strict and lenient matches—overall and by business category—appear in the [Table](#).

The set of observations from 2010 would have correctly identified only two of every five businesses (40%) present on the same street segments in 2015 by strict matching criteria. The probability of a business in 2015 previously being present on the same street segment in 2010 was as high as one in two for restaurants (52%) but only about one in three for both general grocers (29%) and other storefront businesses (36%).

According to lenient criteria, more than one of every two businesses in 2015 had a similar business previously present on the same street segment in 2010 (58%). The proportion was as high as nearly three in four for restaurants (72%) but less than one in two for other storefront businesses (43%).

Compared with the probabilities of a business in 2015 having been present in 2010, the probabilities of a business in 2010 still being present in 2015 were higher according to both strict and lenient criteria. Overall, just over one in two businesses present in 2010 were still present on the same street segments in 2015 (52%). The proportion was as high as nearly two of three for other storefront businesses (63%) and as low as about one of three for specialty food stores (34%).

**Table.** Observations from 2010 compared to observations from 2015 for businesses selling any food/drink on 153 street segments in the Bronx, NY

For businesses selling any food/drink	Overall	General grocers <sup>a</sup>	Specialty-food stores <sup>b</sup>	Restaurants <sup>c</sup>	Other storefront businesses <sup>d</sup>
N in 2010	220	46	19	99	56
N in 2015	285	66	22	99	98
<b>Strict matches between years<sup>e</sup></b>					
How often businesses in 2015 were previously present in 2010, proportion (95% CI)	0.40 (0.35-0.46)	0.29 (0.18-0.41)	0.45 (0.24-0.68)	0.52 (0.41-0.62)	0.36 (0.26-0.46)
How often businesses in 2010 were still present in 2015, proportion (95% CI)	0.52 (0.45-0.59)	0.41 (0.27-0.57)	0.34 (0.18-0.54)	0.52 (0.41-0.62)	0.63 (0.49-0.75)
<b>Lenient matches between years<sup>f</sup></b>					
How often businesses in 2015 were previously present in 2010, proportion (95% CI)	0.58 (0.52-0.63)	0.56 (0.43-0.68)	0.64 (0.41-0.83)	0.72 (0.62-0.80)	0.43 (0.33-0.53)
How often businesses in 2010 were still present in 2015, proportion (95% CI)	0.75 (0.68-0.80)	0.80 (0.66-0.91)	0.83 (0.64-0.94)	0.72 (0.62-0.80)	0.79 (0.66-0.88)

<sup>a</sup>General grocers included one or more of supermarkets, grocery stores, and convenience marts/bodegas.

<sup>b</sup>Specialty food stores included one or more of bakeries, butcher shops, candy stores, fish markets, liquor stores, and produce markets.

<sup>c</sup>Restaurants included one more of bars, coffee shops, delis, fast-food outlets, ice cream parlors, juice bars, pizzerias, and other take-out and table service eateries.

<sup>d</sup>Other storefront businesses offering food/drink included one or more of accounting offices, antique stores, auto repair shops, banks, barber shops, beauty salons, car sales shops, clothing stores, convenience stores, department stores, doctor's offices, dollar stores, electronics stores, furniture stores, gas stations, gift and card shops, gyms, hardware stores, insurance company offices, laundromats, mobile phone stores, musculoskeletal rehab centers, musical-instruments stores, nail salons, newsstands, party-supply stores, pharmacies, real estate offices, supplement stores, tax offices, and vitamin/nutritional-supplement shops.

<sup>e</sup>Strict matches=businesses with the exact same name or consistent name (eg, *Webster Drugs* vs *Webster Pharmacy*) on the same street segment in 2010 and 2015; for proportions: 0=no agreement, 1.00=perfect agreement.

<sup>f</sup>Lenient matches=businesses thought to be similar (eg, *The Best Roma Pizzeria* vs *Papa Lenny Restaurant*) on the same street segment in 2010 and 2015; for proportions: 0=no agreement, 1.00=perfect agreement.

According to lenient criteria, three of every four businesses present in 2010 had a similar business on the same street segment in 2015 (75%). This concordance was highest for specialty food stores (80%); there were more specialty food stores in 2015 that resembled other specialty food stores on the same street segments in 2010 than there were similar correspondences for the other business categories. Lenient concordance was lowest for restaurants (72%).

## DISCUSSION

In the present study, we assessed change in food/drink availability over time, considering a full range of storefront businesses. In the 5-year period from 2010 to 2015, food sources changed substantially, even by lenient standards, particularly with regard to other storefront businesses not normally assessed in food-environment research and in the direction of markedly greater food availability.

Although there were certainly businesses present in 2010 that were not present in 2015 (suggesting changed ownership, shifted business models, or businesses folding), almost one third (30%) more businesses were offering food and/or drink in 2015 than in 2010. Increases occurred within three of four broad business categories: 44% more general grocers, 16% more specialty food stores, and 75% more other storefront businesses. The number of restaurants stayed the same.

The increase in food/drink sources could have been due to new-business development (in the cases of general grocers and specialty food stores) and/or existing businesses taking on food/drink selling (in the cases of other storefront businesses). Regardless, compared with findings for 2010, 22% more of the sampled street segments hosted food/drink-offering storefronts in 2015.

Such substantial changes in the food environment raise the real possibility of faulty conclusions from studies that assume food-environment stability over time. In the present study, the consistency between two sets of data collected 5 years apart was only around or generally less than 50% (see rows for strict matches in the Table). One implication is that if research uses data 5 years or more out of date for exposure assessment (based on the time specified by the study design), the result could be misclassification error. Misclassification error could be differential—that is, related to both exposure (like food-outlet type, as current findings suggest could be the case) and outcome (eg, adolescent body mass index [BMI]). Misclassification error could also be nondifferential—that is, unrelated to exposure or outcome. If there is differential error, the result is bias, creating false associations in either a positive or negative direction. If there is nondifferential error, the result is noise, potentially masking true associations. Both types of error may be problems in the literature to date.

Several food-environment studies have produced unexpectedly null results and/or associations in directions opposite those anticipated.<sup>3-5,30</sup> As a demonstration, a table of published food-environment papers—noting expected, null, or opposite associations and detailing dates of exposure and outcome assessments—is available from the authors on request. The table shows that >10% of the 125 examined studies had asynchrony of ≥5 years between exposure and outcome assessments from the times that study designs specify. As one example, in a cross-sectional study a food-source exposure (living in a block group with certain food-source options) was measured in 2008, but the outcome (BMI based on driver's license data) was measured anywhere from 1995 to 2005. As another example, a longitudinal study measured a food-source exposure (number of fast-food outlets within a 1-kilometer network radius of a child's residential postcode) in 2014, but the outcome (body weight percentile) as a change from 2006/2007 to 2012/2013. In both studies investigators assumed no meaningful change in food source exposure for a period of years (up to 13 years in the case of the first study, up to 8 years in the case of the second). Notably in both studies, time of exposure assessment occurred *after* the time of outcome assessment, contrary to what study design (and conditions necessary to make causal inference) would specify.

Using lenient criteria to assess food-environment changes might improve the situation for some purposes. After all, stability over time assessed leniently was higher in the present study. However, leniency necessitates accepting businesses of a similar type as the same (eg, accepting a submarine [hero/hoagie] sandwich shop in 2010 as equivalent to a fried-chicken outlet in 2015). Such acceptance may suffice in some cases if, based on the research question, differences between specific food sources are less important. However, for most questions related to diet and weight-related health outcomes, it may be important to distinguish, for example, between sandwich shops and fried-chicken outlets. Moreover, even according to lenient criteria, the performance of older data in the present study was mediocre at best and, arguably, unacceptable (agreement for lenient matches was in the range of only 43% to 83%).

Another implication of the present study is the potential problem of ignoring certain food sources. Most food-environment studies focus on general grocers (most often supermarkets) and/or restaurants (most often fast-food outlets),<sup>3-5,30</sup> often to the exclusion of specialty food stores and most, if not all, other businesses.<sup>31</sup> In the present study, in 2010, specialty food stores accounted for 9% of food/drink-offering storefronts, and other storefront businesses accounted for 26%. In 2015, the numbers were 8% and 34%, respectively (ie, fully 42% of the potential food-source exposure). Although a limitation is that these numbers reflect proportions of food/drink sources—not the proportions of all foods/drinks being offered, purchased, or consumed—it would be hard to imagine provision could be negligible as assumed in most studies.<sup>31</sup> After all, businesses are unlikely to offer foods/drinks if they are not selling.

The fact that more businesses seem to be adding food/drink selling to their business models is notable. The results of the present study show that other businesses are the segment of a storefront food-environment exposure having the greatest growth (compared with general grocers,

specialty food stores, and restaurants) and that other storefront businesses (34% of the food/drink-source total) rivaled restaurants (35% of the total) as the most prevalent food/drink sources in 2015. Given that other research shows marked differences in the proportion of other storefront businesses by neighborhood (and in the proportion selling food/drink),<sup>18,19</sup> failing to consider the contribution of such businesses to food-environment exposures could be another source of differential misclassification, bias, false associations, and faulty conclusions in either a positive or negative direction.

The present study is not the first to suggest the potential role of other storefront businesses in food/drink provision<sup>10-19</sup>; however, it is the first study to quantify changes in food-source exposure over time when such businesses are taken into consideration. A strength of the study is that it included examination of a full range of potentially relevant storefronts selling food/drink items. Another strength is that investigators performed separate analyses using two different levels of stringency for matches and considered both forward and retrospective agreement between datasets collected 5 years apart.

The main limitation of the study is a relatively small sample size, owing to the labor-intensive methods for making ground observations and determining matches by two levels of stringency. Regardless, the study sample covered the entire geographic area of the Bronx (see the Figure), and although 95% CIs are relatively wide, even upper limits are not reassuring with regard to food-environment stability. Although investigators cannot comment on the generalizability of findings, nationally there is a trend toward increasing food/drink availability, even from historically less usual sources.<sup>32,33</sup> If changes in food-source exposure are even half as extreme in other locales, the amount of change would still be substantial for some food-source categories according to strict matching criteria.

Given that strict matching criteria in the present study only required businesses to be on the same street segment (not necessarily at the exact same address or GPS coordinates), analyses should be interpreted as liberal. If anything, they minimize actual differences between years and understate the real threats of misclassification error that could result from relying on exposure data collected at times other than when study designs specify.

The design for the present study allowed us to identify businesses that offered foods/dinks in 2010 that no longer did so in 2015 (none did). However, because of different study protocols in 2010 and 2015, we cannot report on the number of businesses that did not offer foods/drinks in 2010 that then started offering them by the time of repeat assessment 5 years later. Again, businesses not offering food/drink were completely excluded from the 2010 data because of the more limited objectives of that earlier assessment.<sup>17</sup> Research to determine adoption rates for food/drink offering by storefronts over time is needed to address this limitation.

Although the present study included a wide range of potential food sources, it was restricted to storefront businesses because of the limited 2010 assessment. In 2015, all food sources were considered; and, for example, there were 23 mobile vendors selling foods/drinks on the 153 sampled streets (more than the number of specialty food stores present in that year). These mobile vendors were not included in current analyses. Research to explore differences in food/

drink offerings from both storefront and other sources (eg, street vendors, farmers' markets) is needed to address these limitations.

Further research is also needed to address time differences of less than 5 years. Certainly, the present study demonstrates substantial food-environment differences over half a decade, but the rate and shape of that change are unclear. Nonetheless, it is unlikely that all change occurred at a single point in time. Other studies have shown substantial, progressive changes over shorter periods, albeit considering only narrow ranges of food/drink sources.<sup>7-9</sup> Even if change were spaced evenly over the 5 years for the present assessment, results would still not be reassuring for the field; food-environment studies would still be flawed if they have even a single year of asynchrony between when exposure assessment actually occurs and when it should occur based on study design.

## CONCLUSIONS

Over 5 years, an urban food environment can change substantially, even by lenient standards that provide generous allowances for stability. In the present study, the number of storefront businesses offering food/drink increased by nearly a third, and the number of streets on which foods/drinks were available increased by nearly a quarter. The offering of food/drink increased across most business types, particularly among other storefront business, which grew from more than one quarter of all storefront food/drink sources in 2010 to more than one third in 2015.

From a community health standpoint, the impact of increasing food/drink availability could be considerable. Having food/drink items in unexpected places might cue people to impulse purchases (and impulse consumption) they did not intend and reinforce a pattern of constant eating.

If findings are generalizable, failure to include other storefront businesses may miss a substantial portion of a food-source exposure, and relying on asynchronous data may risk substantial error. At best, the cost is imprecision and weakened or falsely null findings in studies linking food availability to diet or diet-related health outcomes. At worst, the cost is inaccuracy and the potential for untrue positive or negative associations.

Food-environment researchers should be mindful of these considerations, noting that potentially erroneous conclusions may lead to misguided interventions (such as siting new produce markets in food deserts that do not actually exist). As the field moves forward, it will be important to consider a full range of potentially relevant food sources and changes in food offerings over time.

Cross-sectional studies will need to be strict about concurrently measuring presumed independent variables (exposures such as proximity to food/drink outlets) and presumed dependent variables (outcomes such as dietary intake or BMI) at a single point in time. Longitudinal studies will need to verify that exposures (eg, food/drink sources around a child's home at a given age) precede outcomes (eg, body weight at a later age) and that exposures are either stable over time or that analyses factor in the effect of change (eg, an increasing density of food/drink sources as the child ages). Regardless of study design, it will also be important to appreciate that food-source exposures at present seem to be expanding in general, both within businesses and onto

new streets. There may be more and more places to obtain food/drink in local environments, and researchers and communities should be aware.

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## STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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## ETHICAL STANDARDS DISCLOSURE

This study did not involve human subjects. Analyses included data from two earlier studies: The study from 2010 was considered exempt by the Albert Einstein College of Medicine Institutional Review Board; the study from 2015 was approved by the same institutional review board under federal regulations 45 CFR 46.110 and 21 CFR 56.110.

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## AUTHOR CONTRIBUTIONS

S. C. Lucan conceived the study, performed the literature review, designed the data collection protocols in both years, oversaw primary data collection in both years, performed all analyses, and drafted the manuscript, including the table. A. R. Maroko assisted with analyses and data interpretation, created the map, and helped revise the manuscript. A. N. Patel and I. Gjonbalaj performed primary data collection in 2015, assisted with data analysis and interpretation, and helped revise the manuscript. S. Rettig and C. Abrams helped clean the data, make "match" determinations, and revise the manuscript. B. Elbel assisted with conceiving and designing the study and revising the manuscript. C. B. Schechter oversaw and assisted with data analysis and helped revise the manuscript.