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Associations of neighbourhood food retail with disability and death in older adults: Cardiovascular Health Study

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ABSTRACT

Background A healthier diet is associated with lower chronic disease burden, but the impact of neighbourhood food environments on disability and death in older adults is not known.

Methods In the Cardiovascular Health Study, a cohort study of adults aged 65+, we calculated study years until death (years of life (YOL)), study years without activities of daily living (ADL) difficulty (years of able life; YoAL) and percent of study years without ADL difficulty (compression of disability). Linear regression quantified associations of food establishments within 5 km of baseline home address (as a z-score) with each outcome, adjusted for sociodemographic characteristics. Sensitivity analyses considered adjustment for risk factors and comorbidities, multiple imputation, alternate neighbourhood definitions (1-km radial buffer, census tract) and restriction on residential stability.

Results We included 4298 participants followed for up to 26 years. All food retail establishments were associated with 6 months higher YoAL per SD in the main model (beta, 0.50 years; 95% CI 0.01, 0.98; p=0.046), with similar findings across sensitivity analyses except when restricting on residential stability. Supermarkets and produce markets were associated with compression of disability (beta, 2.31; 95% CI, 0.04, 4.57) and when using 1-km buffers with YOL (beta, 0.23 years; 95% CI 0.03, 0.43) and YoAL (beta, 0.21 years; 95% CI 0.01, 0.41). Non-supermarket food stores were associated with YoAL (beta, 0.67 years; 95% CI, 0.07, 1.27) and compression of disability (beta, 3.03; 95% CI 0.44, 5.62), but significance was not consistent across sensitivity analyses. Fast-food restaurants did not reach statistical significance in any model.

Conclusion All food retail was associated with YOL without impairment. Neighbourhood food retail access and type may both have roles in extending YOL and years of able life among older adults, but the findings were sensitive to decisions made during measurement and modelling.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The neighbourhood food retail environment can influence individuals' dietary options and choices.

⇒ In older adults, a healthier diet and lifestyle have been associated with compression of disability—that is, an increase in the overall proportion of life lived without disability.

WHAT THIS STUDY ADDS

⇒ After adjustment for neighbourhood and participant health and demographic factors, more food retail of any kind was associated with longer disability-free life expectancy in older adults.

⇒ While healthy food stores (supermarkets and produce markets) and non-supermarket food stores within 5 km were associated with compression of disability, the pattern and significance varied across sensitivity analyses using other neighbourhood definitions.

⇒ Statistically significant associations were not identified for fast-food restaurants with longevity, disability-free years or compression of morbidity.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Although food quality is undeniably important, availability of food retail by type did not predict outcomes consistently; until larger studies can be conducted, availability across all food retail may be more promising in extending disability-free years in older adults.

INTRODUCTION

Cardiovascular disease remains the leading cause of death in adult women and men in the USA.[1] Furthermore, targeting modifiable risk factors like hypertension and diabetes has potential to prevent up to 80% of cardiovascular disease,[2] and diet has been associated with these risk factors. In addition, obesity itself has been independently associated with increased mortality in younger to middle aged adults (ages 20–40),[3–5] although the relationship between obesity and mortality in older adults is controversial.[6 7] Despite this, obesity tends to be associated with higher levels of disability in all age groups.[6 8]

Although a healthy diet has been associated with reduced chronic disease burden including cardiovascular disease[9] and a longer period of life lived without disability (ie, compression of disability),[8] it is less clear how dietary modification to facilitate healthy eating can be sustainably achieved. In addition to approaches that target individuals, the built environment is increasingly recognised as a contributor to dietary quality and obesity.[10] The built environment includes neighbourhoods' buildings, restaurants and shops, a subset of which can be described as the neighbourhood food environment.[11] Documenting contributions of neighbourhood food environments to reducing obesity and promoting health across the lifespan is especially important because built environment alterations may lead to expansive and sustained changes in dietary intake and physical activity as compared with clinical or individually targeted health behaviour change alone.[12 13] The density of healthy food retail (such as supermarkets and produce markets) versus unhealthy food retail (such as fast-food restaurants) has been associated with corresponding body mass index (BMI) of its residents in selected US cities[14–16] and globally,[17] and availability of food retail by type has been associated with cardiovascular disease.[18–21] Simultaneously, racial and socioeconomic inequities in the built environment appear to impact obesity and chronic disease risk.[22–24] However, the presence of healthy food establishments has not consistently been associated with cardiovascular disease incidence when measured at 1- or 5-km buffers[25] or cardiovascular mortality when measured at ZIP Code Tabulation Area or census tract levels;[26] a recent systematic review highlighted variation in risk of bias for studies of food retail and cardiovascular disease and limited attention to food retail types beyond fast-food restaurants.[18] The association of neighbourhood food retail with disability among older adults has depended on methods of assessing the environment[27] or on multimorbidity.[28]

Given the relationship of neighbourhood food environment with diet, and the concomitant relationship of diet with chronic disease, one might expect neighbourhood food retail environments to impact overall disability and death, which are valued clinical outcomes, yet evidence to support these associations is equivocal. To add to this literature, we used objective food retail establishment data throughout the USA to characterise the area surrounding baseline home addresses for a cohort of older adults and analysed associations with time to disability and death.

METHODS

The Cardiovascular Health Study (CHS) is a longitudinal cohort study of 5888 adults aged 65 years and older designed to understand risk factors associated with development of cardiovascular disease and stroke in older adults.[29] Starting in 1989, 5201 participants were recruited from 4 US communities (Sacramento, CA; Hagerstown, MD; Winston-Salem, NC; and Pittsburgh, PA) using a random sample of Medicare eligibility lists. A second cohort of 687 predominantly African-American participants was recruited from three of the original clinic sites in 1992–1993. Participants were eligible if they were 65 years of age or older; demonstrated capacity for informed consent; were not wheelchair users; and were not receiving chemotherapy, radiation therapy or hospice services. Recruitment and periodic follow-up efforts were completed both by telephone and in person including health surveys, physical examination, laboratory measurements and selected imaging. For these analyses, we truncated follow-up at 26 years.

Exclusion criteria

Out of 5888 CHS participants, for privacy reasons, only participants deceased as of August 2016 (n=5384) were phenotyped for their residential history throughout cohort follow-up[30] and corresponding neighbourhood retail characteristics.[31] The residential history linkage used a commercially available public records database, though prior work suggests the added value beyond addresses archived by the cohort study team is limited, particularly for older adult populations.[32] Participants were further excluded if home address was not successfully geocoded or they were missing any area-level covariate data (n=4417). While this sample was included in analyses with multiple imputation of missing individual-level covariate data, the final analytic sample for complete case analyses restricted to 4298 participants without missing sociodemographic, behavioural or comorbidity data (online supplemental figure 1).

Area-based characteristics including neighbourhood food environment

Area-based characteristics were collected for 5-km radial buffers surrounding each CHS participant's geocoded baseline home address. Baseline address was operationalised as the first address available within the first 5 years after baseline for each participant (addresses were from no later than 1994 for the original cohort recruited in 1989–1990 and no later than 1997 for the second cohort recruited in 1992–1993).

Alternative neighbourhood definitions for measurement were 1-km radial buffers, which better approximate the immediate environment potentially accessible by walking, or census tracts, which have the property of being larger in low population density settings where food acquisition may be especially reliant on vehicle travel. About 44% of respondents moved to a different census tract during the study period, with the remainder of participants identified as residentially stable.

Our primary exposures of interest were food retail establishment counts based on classified National Establishment Time Series data.[31] Neighbourhood food retail estimates were based on the annual data from the same year in which address data were first available or carried backward from 1990. For each establishment, we used location (77 million addresses across the continental USA which were re-geocoded by the research team to improve match rate, location accuracy and consistency of methods over time) and Standard Industrial Classification (SIC) code.[33] For some categories, SIC codes were used alongside

Table 1 Baseline characteristics of Cardiovascular Health Study participants, stratified by tertiles of all food retail establishments (n=4298)

		Count of all food retail (stores and restaurants) in 5-km radius buffer		
	Total (n=4298 participants) % or mean (SD)	Tertile 1: low (0 to 138) (n=1441 participants) % or mean (SD)	Tertile 2: middle (139 to 281) (n=1425 participants) % or mean (SD)	Tertile 3: high (282 to 5312) (n=1432 participants) % or mean (SD)
Age (years)	73.3 (5.6)	73 (5.6)	73.3 (5.7)	73.5 (5.6)
White	91%	94%	90%	88%
Female	56%	58%	56%	54%
Married	67%	69%	67%	65%
> High school education	43%	35%	41%	52%
Ever smoker	55%	51%	56%	58%
Current alcohol use	51%	42%	49%	62%
BMI (kg/m^2)	26.5 (4.6)	26.4 (4.5)	26.5 (4.7)	26.5 (4.5)
Self-rated health				
Excellent	13%	12%	13%	14%
Very good	25%	24%	23%	26%
Good	37%	37%	37%	38%
Fair	21%	22%	23%	19%
Poor	4%	4%	4%	4%
Comorbidities				
Diabetes	16%	17%	16%	16%
Hypertension	66%	68%	65%	66%
Myocardial infarction	11%	11%	10%	12%
Congestive heart failure	5%	4%	6%	4%
Stroke	4%	4%	5%	4%
Clinic site				
Winston-Salem, NC	26%	47%	29%	0%
Hagerstown, MD	22%	32%	32%	1%
Sacramento, CA	27%	15%	26%	39%
Pittsburgh, PA	26%	6%	12%	60%
Area-level characteristics				
Population density (per km^2)	1225 (1037)	311 (243)	930 (431)	2439 (764)
Unemployment rate (%)	5.9 (2.2)	4.4 (1.7)	5.7 (1.8)	7.7 (1.6)
Median household income (USD)	$52 027 ($13 184)	$60 527 ($12 519)	$53 153 ($10 012)	$42 353 ($9838)
All food retail establishments	241.2 (213.4)	54.7 (43.0)	196.0 (39.4)	473.8 (205.2)
Fast-food restaurants (count)	31.8 (23.3)	8.1 (8.1)	32.4 (10.4)	54.9 (18.9)
Non-supermarket food stores (count)	98.6 (84.5)	23.8 (17.5)	79.7 (15.3)	192.6 (78.0)
Healthy foods stores (count)	12.2 (9.1)	3.4 (2.8)	11.0 (3.0)	22.2 (7.3)

national chain names, word searches and sales volumes. Food retail categories included (i) all food retail, a count of restaurants (fast-food outlets, ethnic restaurants, coffee shops, pizza stores and others) and food stores (supermarkets and produce markets identified as healthy food stores and others identified as non-supermarket food outlets); (ii) fast-food restaurants, establishments that serve highly processed foods requiring low preparation time, expected to be eaten cafeteria style (eg, lacking waiter service) or for take-out; (iii) non-supermarket food stores (including corner stores, bodegas and convenience stores); and (iv) healthy food stores, those establishments selling fresh food items for preparation at home (fresh fruit and vegetable markets and supermarkets).

Area-based sociodemographic characteristics were estimated using longitudinally harmonised population census data.[34] Neighbourhood sociodemographic characteristics were estimated based on linear interpolation between 1990 and 2000 or carried backward from 1990.

Remaining years of life, years of able life and compression of disability

Study participants were followed for up to 26 years. Deaths have been identified and confirmed from a combination of sources including: 6-month telephone outreach, proxy interviews, obituaries, medical records, death certificates and the national death index. Regardless of the method for initial identification of a potential death, additional records were sought to inform adjudication of cause of death, such that most deaths were corroborated across multiple sources. Years of life (YOL) was defined as the time from study enrolment to death for each participant. Because all participants who underwent phenotyping of the built environment were deceased (ie, with no censoring), we used remaining YOL rather than survival methods.

Participants were surveyed on a semiannual or annual basis throughout follow-up about any difficulty in completing activities of daily living (ADL) defined as: walking around home, getting out of bed, eating, dressing, bathing or using the toilet. We defined years of able life (YoAL) as study years in which participants did not experience any difficulties completing ADL tasks; missing ADL data were addressed by transforming to a scale that ranged from no ADL limitation to deceased, after which time points with missing ADL limitation data were linearly imputed, as previously described.[35]

Compression of disability was defined as YoAL divided by YOL, with a maximum value of 100% representing that all remaining years were without ADL difficulty.

Statistical methods and sensitivity analysis

We constructed multivariable linear regression models to quantify associations between neighbourhood food environment measures and each of our three outcomes: YOL, YoAL and compression of disability. Following examination of Pearson's correlation coefficients (online supplemental figure 2, Table 1), our modelling approach included only one food environment measure at a time. Food environment measures were rescaled as z-scores, allowing interpretation of estimates of association as per SD.

Our primary analyses adjusted for baseline covariates previously associated with life expectancy in older adults including age, race, sex, marital status, education level and clinic site. Additionally, we adjusted for neighbourhood demographic factors including population density, unemployment rate and median household income as potential confounders.[36] Extensive adjustment to include baseline health behaviour and comorbidity burden was considered a secondary analysis because of the risk that this could represent overadjustment depending on whether these determinants of life expectancy are better conceived as mediators (effects resulting from the food environment and along the causal pathway to death and disability) or potential confounders (causes influencing decisions about where to live and thus common prior causes of the exposure of interest and outcome). Extensively adjusted models included covariates in the main analysis plus smoking (never, former, current), alcohol use (any use vs no use), BMI, self-rated health, diabetes, hypertension (systolic blood pressure ≥140/90 or taking antihypertensive medications at baseline), prevalent myocardial infarction, congestive heart failure and stroke.

Because of potential for bias in our complete case analyses due to missing at random data, we repeated our main analysis with multiple imputation of missing covariate data; all variables in the analyses, including outcomes, were used during imputation of missing covariate values by chained equations. We used the 'mice' R package to generate multiply imputed data and pooled results (m=5).[37]

We additionally conducted sensitivity analyses for geographic unit (1-km buffers or census tracts for food environment and area-based sociodemographic measures) and restriction to residentially stable participants (those at their baseline census tract throughout follow-up). We explored potential effect modification for the association between count of each food retail type with each outcome, considering statistical interaction with race, sex or clinic site.

Statistical significance was defined conventionally as a p value less than 0.05. Geographic analyses were performed in ArcGIS version 10.6; R V.4.3.2 was used for data processing and statistical models.

Patient and public involvement

No patients or public were involved in the development, design or conduct of this study. Participant resources and dissemination of findings back to participants from the CHS included online materials and newsletters.

RESULTS

Baseline characteristics

Of the 4298 CHS participants included, the mean age was 73 years at baseline, 56% were female, 91% identified as white, 67% were married, and 43% had completed educational attainment beyond high school (table 1). Participants living in neighbourhoods with the highest tertile (282 to 5312 food stores or restaurants within 5-km buffer) of food retail differed in several ways from those in the lowest tertile (0 to 138 food stores or restaurants within 5-km buffer), including higher education, more current alcohol use and living in areas with greater population density. Notably, BMI and comorbidities at baseline showed no strong dose-response relationship across tertiles for count of all food retail. There were differences noted by clinic site, with the highest tertile of food stores and restaurants observed almost exclusively

Table 2 Adjusted associations between neighbourhood food establishments within a 5-km buffer at baseline and years of life (YOL), years of able life (YoAL) and compression of disability

	Main adjusted models*		Extensively adjusted models†		Multiply imputed models*	
	Increment per 1 additional SD food establishments (95% CI)	P value	Increment per 1 additional SD food establishments (95% CI)	P value	Increment per 1 additional SD food establishments (95% CI)	P value
YOL (years)						
All food retail establishments	0.31 (–0.19, 0.81)	0.225	0.32 (–0.14, 0.79)	0.175	0.41 (–0.07, 0.89)	0.093
Fast-food restaurants	–0.12 (–0.46, 0.22)	0.496	–0.10 (–0.42, 0.22)	0.538	–0.08 (–0.42, 0.26)	0.656
Non-supermarket food stores	0.23 (–0.39, 0.85)	0.463	0.20 (–0.38, 0.78)	0.503	0.36 (–0.22, 0.94)	0.224
Healthy foods stores	0.06 (–0.48, 0.60)	0.823	–0.02 (–0.53, 0.49)	0.944	0.02 (–0.51, 0.56)	0.937
YoAL (years)						
All food retail establishments	**0.50 (0.01, 0.98)**	**0.046**	**0.50 (0.05, 0.95)**	**0.029**	**0.58 (0.11, 1.05)**	**0.015**
Fast-food restaurants	–0.15 (–0.48, 0.19)	0.393	–0.14 (–0.45, 0.17)	0.369	–0.12 (–0.45, 0.21)	0.476
Non-supermarket food stores	**0.67 (0.07, 1.27)**	**0.030**	**0.59 (0.03, 1.14)**	**0.037**	**0.74 (0.18, 1.31)**	**0.010**
Healthy food stores	0.38 (–0.15, 0.90)	0.163	0.25 (–0.23, 0.74)	0.306	0.32 (–0.20, 0.85)	0.225
Compression of disability (%)						
All food retail establishments	1.85 (–0.24, 3.94)	0.083	**2.05 (0.11, 3.99)**	**0.038**	1.83 (–0.17, 3.84)	0.074
Fast-food restaurants	0.05 (–1.39, 1.48)	0.950	0.10 (–1.24, 1.43)	0.886	0.11 (–1.32, 1.53)	0.883
Non-supermarket food stores	**3.03 (0.44, 5.62)**	**0.022**	**2.88 (0.48, 5.29)**	**0.019**	**2.75 (0.31, 5.19)**	**0.027**
Healthy food stores	**2.31 (0.04, 4.57)**	**0.046**	1.94 (–0.17, 4.04)	0.071	2.04 (–0.21, 4.29)	0.076

Bold font indicates statistically significant finding (p<0.05). In complete case analyses n=4298 and for analyses with covariate imputation n=4417.
*Adjusted model includes participant age, race, sex, marital status, education level, clinic site and area-based sociodemographic factors including population density, percent unemployment rate and household income.
†Fully adjusted model includes all covariates in adjusted model plus baseline health behaviour and comorbidity burden: smoking status, alcohol use, body mass index, self-rated health, diabetes, hypertension, myocardial infarction, congestive heart failure and stroke.

in Sacramento and Pittsburgh. Supplemental descriptive tables show differences in participant characteristics across clinic sites at recruitment (online supplemental table 2) and for those who were excluded due to missing geographic data (online supplemental table 3).

Fast-food restaurants, non-supermarket food stores and healthy food stores each increased across tertiles of all food retail (table 1). Food establishment counts and geographic covariates were correlated (online supplemental figure 2), and correlations among food establishment counts persisted even after accounting for population density (online supplemental table 1).

Associations with years of life and disability-free years

The mean (SD) YOL was 13.0 (6.5) years, and the mean YoAL was 9.1 (6.3) years.

After adjustment of participant and area-based sociodemographic factors, for each one additional SD of food retail establishments, YoAL was 0.50 years greater, corresponding to about 6 months of disability-free life per 213 additional establishments (95% CI 0.01 to 0.98; table 2). We observed a similar but slightly stronger association for non-supermarket food stores where one additional SD of non-supermarket food stores (85 additional establishments) corresponded to 0.67 additional years (8 months) of disability-free life (95% CI 0.07, 1.27) (table 2). Both non-supermarket food stores and healthy food stores (supermarkets and produce markets) were associated with greater compression of disability (beta, 3.03; 95% CI 0.44, 5.62; and beta, 2.31; 95% CI, 0.04, 4.57; table 2). Covariate associations are shown with each of the outcomes from the main analyses with a 5-km buffer (online supplemental tables 4-6). Of the geographic covariates, median household income reached or approached statistical significance in models of both YOL and YoAL.

In extensively adjusted analyses (table 2), the significant trend for those living in areas with higher counts of all food retail or higher non-supermarket food stores to have higher YoAL persisted; one additional SD of all

Table 3 Sensitivity analyses using 1-km buffer or census tract for neighbourhood food environment and area-based characteristics and years of life (YOL), years of able life (YoAL) and compression of disability (n=4298)

	1-km buffer, adjusted models*		Census tract, adjusted models*	
	Increment per 1 additional SD food establishments (95% CI)	P value	Increment per 1 additional SD food establishments (95% CI)	P value
YOL)(years)				
All food retail establishments	**0.34 (0.08, 0.60)**	**0.011**	**0.21 (0.03, 0.40)**	**0.026**
Fast-food restaurants	0.17 (−0.05, 0.40)	0.136	0.17 (−0.02, 0.36)	0.076
Non-supermarket food stores	0.26 (0.00, 0.51)	0.051	0.17 (−0.02, 0.35)	0.079
Healthy foods stores	**0.23 (0.03, 0.43)**	**0.026**	**0.20 (0.02, 0.38)**	**0.031**
YoAL (years)				
All food retail establishments	**0.40 (0.15, 0.66)**	**0.002**	**0.20 (0.02, 0.38)**	**0.033**
Fast-food restaurants	0.20 (−0.02, 0.42)	0.073	0.13 (−0.06, 0.31)	0.178
Non-supermarket food stores	**0.34 (0.08, 0.59)**	**0.009**	0.18 (0.00, 0.36)	0.055
Healthy food stores	**0.21 (0.01, 0.41)**	**0.038**	0.12 (−0.05, 0.30)	0.172
Compression of disability (%)				
All food retail establishments	0.36 (−0.72, 1.45)	0.512	**1.03 (0.25, 1.81)**	**0.010**
Fast-food restaurants	0.06 (−0.89, 1.01)	0.900	0.50 (−0.28, 1.29)	0.210
Non-supermarket food stores	0.47 (−0.61, 1.55)	0.396	**1.07 (0.30, 1.84)**	**0.007**
Healthy food stores	0.81 (−0.04, 1.66)	0.063	0.53 (−0.22, 1.29)	0.165

Bold font indicates statistically significant finding (p<0.05).
*Adjusted model includes participant age, race, sex, marital status, education level, clinic site and area-based sociodemographic factors including population density, percent unemployment rate and household income.

food retail (213 additional establishments) was associated with 0.50 additional years (6 months) of disability-free life (95% CI 0.05, 0.95), and one additional SD of non-supermarket food stores (85 additional establishments) was associated with 0.59 additional years (7 months) of disability-free life (95% CI 0.03, 1.14). Both all food retail and non-supermarket food stores were associated with compression of disability (beta, 2.05; 95% CI 0.11, 3.99; and beta, 2.88; 95% CI, 0.48, 5.29; table 2). The three associations that were present across both main adjusted and extensively adjusted models also retained statistical significance and were similar in magnitude following multiple imputation (table 2).

Across neighbourhood definition sensitivity analyses, count of all food retail remained significantly associated with higher YoAL (table 3). The effect size was estimated to be somewhat lower at 0.40 additional years of disability-free life (4.8 months) per one additional SD of all food retail within 1 km (23 additional establishments) (95% CI 0.15 to 0.66) as compared with the main analysis estimate of 6 months per SD of establishments within 5 km. Associations were also noted for all food retail with greater YOL in the 1 km and census tract analyses (table 3), which had not reached significance in the 5-km analyses (table 2). Healthy food stores were associated with greater YOL and greater YoAL in the 1-km analyses and with YOL only in the census tract analyses (table 3). In analyses that used census tracts as the geographic unit, associations were noted to reach significance for all food retail and for non-supermarket food stores with compression of disability (beta, 1.03; 95% CI 0.25, 1.81; and beta, 1.07; 95% CI, 0.30, 1.84, table 3).

Among 2425 residentially stable participants, no food environment associations were statistically significant across the three outcomes; trends for healthy food stores were in the opposite of the expected direction for both YOL and YoAL (online supplemental table 7). To support interpretation of our results scaled as per SD, descriptive statistics for food environment measures across sensitivity analyses are provided in online supplemental table 8.

Interactions by race, sex and clinic site

We further explored statistical interaction with clinic site. We found statistically significant interactions for site in models of compression of disability and YoAL. Count of all food retail was more strongly associated with compression of disability among those recruited in Sacramento or Hagerstown (online supplemental table 9). Fast-food stores had an interaction term suggesting an inverse association with YoAL in Pittsburgh. Race and sex interaction terms were examined but were not statistically significant.

DISCUSSION

In this longitudinal cohort of 4298 community dwelling older adults, we observed that all food retail near the baseline home address was associated with more years free of difficulty with ADLs. All models were adjusted for individual and area-based sociodemographics, and for some associations, statistical significance differed depending on inclusion of more extensive adjustment, multiple imputation, study site or which geographic boundaries used for food retail and covariate measurement suggesting that findings are sensitive to analysis choices. Retail counts specific to healthy food stores (produce markets and supermarkets) showed an association with more YOL for which significance and magnitude depended on the geographic unit used (significant for 1 km and census tract analyses but not 5 km) and trended in the opposite of the expected direction for 5-km analyses restricted to residentially stable older adults.

Although studies assessing self-reported diet quality have found benefits associated with consumption of vegetables, legumes, fruits, nuts, cereals, fish and seafood in reducing all-cause mortality in older adults,[38] the impact of neighbourhood food retail environment on health outcomes in adults has been harder to ascertain. Our study adds to the equivocal evidence available in prior literature.[18 27 28] Prior studies assessing the impact of supermarkets and fast-food retail environment with more proximal outcomes have considered adult dietary habits, BMI and obesity, yielding mixed results.[17 39–42] We have previously shown increasing trends in food retail establishment counts over time throughout the USA, although varying by type of establishment.[43] Such longitudinal change has been leveraged in an attempted to isolate the effect of gaining new neighbourhood healthy food store availability on cardiovascular disease incidence in the CHS cohort with null findings,[25] which together with the present equivocal findings for challenges assumptions in the field about likely benefits for longevity and compression of morbidity.

There are several limitations to this analysis. First, this is an observational study with a focus on food retail measured at baseline which limits our ability to infer causal relationships, although randomised assignment of individuals to long-term residence in different environments is not feasible. Second, our study participants are adults aged 65 years and older at baseline, and our study cannot determine how cumulative exposure to food retail environment at younger ages might have shaped an earlier trajectory of morbidity. Related to incomplete lifetime residential history, the study was unable to account for differences in the length of time spent in the neighbourhood prior to baseline; we were likewise unable to establish the direction of causation between baseline neighbourhood food environment and potential confounders included only in our extensively adjusted models. For example, the higher prevalence of current alcohol use in the top tertile of food store and restaurant availability could result from the food environment influencing intake or alcohol intake habits promoting self-selection into residential neighbourhoods with more stores and restaurants. Third, we may not have optimally classified food retail establishments for their effect on YOL. For example, although supermarkets are categorised as institutions offering ‘healthy foods’, individuals may elect to purchase and consume unhealthy dietary options (eg, highly processed food) from these establishments. In addition, we are not able to ascertain how or if CHS participants may have used these establishments or indeed whether the participants whose health and longevity was measured were the individuals responsible for food procurement or meal preparation. Associations may instead arise due to residual confounding from neighbourhood socioeconomic factors, despite our best efforts to control for these factors in our model. Fourth, there is limited ethnic diversity in the CHS cohort, which limits the generalisability of our findings particularly to Latinx and Asian populations of older adults, and the recruitment site-specific findings suggest that associations are not uniform across geographic settings.

Despite these limitations, we are uniquely positioned to explore any potential relationships between the food retail environment on life expectancy, disability-free life expectancy and compression of disease due to several factors. First, the study provided a comprehensive follow-up period of over two decades and vital status ascertainment was complete for all participants in the study, which allowed us to calculate exact remaining YOL rather than estimating it. While associations were detectable as statistically significant with a magnitude between 3 and 9 months per SD higher food retail establishment count, this may represent a food retail contrast that is larger than what can be feasibly achieved through re-zoning or other place-based initiatives. Second, we have access to a combination of detailed data sources for each participant, including clinical data and geographic variables derived from commercially licensed and population census data, which allow us to adjust our analyses not only for participant factors but also individual and area-based sociodemographic factors that have an undeniable impact on life expectancy.[44]

CONCLUSION

In analysis of community dwelling older adults and their neighbourhood food retail environment in settings across the USA, all food stores and restaurants were associated with more YoAL. Both magnitude and significance of results for healthy food retail were sensitive to modelling and measurement choices. Given these findings, availability across all food retail may be at least as important as establishment type in opportunities for extending longevity and able life for older adults.

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MAH performed the data analysis, and KJM and GS supervised the data analysis. RB wrote the manuscript, and all authors provided significant feedback regarding all analyses and conclusions. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. GSL is the guarantor. Corresponding author GSL affirms that the manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained. The corresponding author has the right to grant on behalf of all authors and does grant on behalf of all authors, a worldwide license to the Publishers and its licensees in perpetuity, in all forms, formats and media (whether known now or created in the future), to (i) publish, reproduce, distribute, display and store the contribution; (ii) translate the contribution into other languages, create adaptations, reprint, include within collections, and create summaries, extracts and/or abstracts of the contribution; (iii) create any other derivative work(s) based on the contribution; (iv) exploit all subsidiary rights in the contribution; (v) the inclusion of electronic links from the contribution to third party material wherever it may be located; and (vi) license any third party to do any or all of the above.

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Ethics approval This study involves human participants. The study involves human subjects, and the link to geographical data was approved by the Drexel University Institutional Review Board protocol number 1612004989R007. Secondary analyses were deemed exempt from IRB review by Beth Israel Deaconess Medical Center's IRB as it utilised de-identified, publicly available data. Participants gave informed consent to participate in the study before taking part.

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Data availability statement Data may be obtained from a third party and are not publicly available. Data may be obtained by contacting the Cardiovascular Health Study https://www.nhlbi.nih.gov/science/cardiovascular-health-study-chsand the built environment data may be obtained by contacting the Lovasi Lab gslovasiresearch@gmail.com.

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