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Socio-economic status, neighbourhood food environments and consumption of fruits and vegetables in New York City

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Abstract

Objective: Recommendations for fruit and vegetable consumption are largely unmet. Lower socio-economic status (SES), neighbourhood poverty and poor access to retail outlets selling healthy foods are thought to predict lower consumption. The objective of the present study was to assess the interrelationships between these risk factors as predictors of fruit and vegetable consumption.

Design: Cross-sectional multilevel analyses of data on fruit and vegetable consumption, socio-demographic characteristics, neighbourhood poverty and access to healthy retail food outlets.

Setting: Survey data from the 2002 and 2004 New York City Community Health Survey, linked by residential zip code to neighbourhood data.

Subjects: Adult survey respondents (*n* 15 634).

Results: Overall 9·9 % of respondents reported eating ≥5 servings of fruits or vegetables in the day prior to the survey. The odds of eating ≥5 servings increased with higher income among women and with higher educational attainment among men and women. Compared with women having less than a high-school education, the OR was 1·12 (95 % CI 0·82, 1·55) for high-school graduates, 1·95 (95 % CI 1·43, 2·66) for those with some college education and 2·13 (95 % CI 1·56, 2·91) for college graduates. The association between education and fruit and vegetable consumption was significantly stronger for women living in lower- *v.* higher-poverty zip codes (*P* for interaction < 0·05). The density of healthy food outlets did not predict consumption of fruits or vegetables.

Conclusions: Higher SES is associated with higher consumption of produce, an association that, in women, is stronger for those residing in lower-poverty neighbourhoods.

Keywords
Fruit and vegetable consumption
Sociodemographic characteristics
Neighbourhood food environment
Multilevel analysis

High fruit and vegetable consumption has been shown to be protective against CVD[1,2] and type II diabetes[3–5], and it correlates with low BMI[6,7]. Given the striking increase in obesity in the USA in recent years[8], it comes as no surprise that fruit and vegetable consumption is low and, by some measures at least, is declining[9]. Higher individual or household socio-economic status (SES) is consistently associated with fruit and vegetable consumption; however, the role of neighbourhood contextual factors is less well understood[10,11]. Recent research has highlighted neighbourhood resources, in particular the food environment, as potential influences on healthy behaviours such as fruit and vegetable consumption[12,13]. There is some evidence that neighbourhood SES is associated with consumption of a healthy diet[14], that low-income neighbourhoods have fewer supermarkets and other food outlets selling healthy foods[15–18], and that access to supermarkets or large grocery stores is associated with healthy diets[15] or consumption of fruits and vegetables[19–24]. However, the evidence has not been uniformly positive, with some studies finding null effects for these neighbourhood contextual measures[24,25].

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Although most studies have examined the independent effects of individual- and neighbourhood-level characteristics, it is possible that individual- and neighbourhood-level factors interact in predicting healthy behaviours such as diet[10,26]. Individual income and education may provide economic resources and/or knowledge that motivates or enables healthy behaviour, but these individual characteristics may not be expressed as such unless those individuals have access to a supportive environment. For instance, a high-SES individual who lives in a 'food desert' may have the resources to purchase healthy foods but lack the opportunity to do so. Previous research found evidence of interactions between individual- and neighbourhood-level SES in predicting BMI[27]. The inverse association observed between higher individual-level SES and BMI was significantly stronger in low-poverty as compared with high-poverty neighbourhoods, suggesting that in high-poverty neighbourhoods there were barriers to the actualization of the advantages afforded by a higher SES.

The current study conducts a parallel analysis to determine whether individual- and neighbourhood-level SES interact to predict fruit and vegetable consumption. In addition, associations between neighbourhood food access and fruit and vegetable consumption are assessed, and analyses are conducted to determine whether disparities in neighbourhood food access explain interactions between individual- and neighbourhood-level SES.

Methods

Data for the present study come from the 2002 and 2004 New York City (NYC) Community Health Survey (CHS), which is a random-digit-dial telephone survey conducted annually by NYC's Department of Health and Mental Hygiene[28–30]. The 2002 (*n* 9672) and 2004 (*n* 9580) CHS surveys asked 'How many total servings of fruit and/or vegetables did you eat yesterday?' and the count of servings was recorded. The CHS is modelled after the Behavioral Risk Factor Surveillance System (BRFSS) as a surveillance tool for health behaviours and conditions. The CHS sampling frame is based on United Hospital Fund (*n* 34) neighbourhoods, which are administrative units comprising two to eight contiguous zip codes and are used for health surveillance and resource planning. Using the respondent's self-reported residential zip code, the 2002 and 2004 CHS data were pooled and linked to geospatial data on zip code-level sociodemographic and built-environment characteristics. Several zip codes with low residential populations, and thus few CHS respondents, were merged with larger neighbouring zip codes to preserve the anonymity of the data. In instances where there were several neighbouring zip codes to which a small zip code might be merged, zip codes with the most similar sociodemographic characteristics were chosen as the merge partner. Zip code-level sample weights for the pooled 2002 and 2004 data were estimated by the Department of Health and Mental Hygiene using constrained raking to race/ethnicity and age and sex totals from the 2000 Census.

Analysis data on reported fruit and vegetable consumption were dichotomized to indicate those reporting eating five or more servings daily *v.* those eating fewer than five servings daily. This approach follows a commonly used threshold in public health interventions[31] and in the research literature[32]. Individual-level measures of SES from the CHS were the ratio of family income to the federal poverty threshold ($US 17 603 for a family of four) and educational attainment. The individual-level data collected in the CHS were augmented with several variables defined at the zip code level. Three variables derived from the 2000 Census data reflected the neighbourhood ethnic and economic context: (i) poverty rate, defined as the proportion of households below the federal poverty level; (ii) percentage of residents reporting black as their race; and (iii) percentage of residents reporting Hispanic as their ethnicity. Additionally, as described previously, using 2005 Dun & Bradstreet business listing data, a measure of zip code-level access to retail outlets selling healthful foods was created: the sum of supermarkets, fruit and vegetable markets and health-food stores divided by the land area of the zip code, a density measure that is conceptualized as access to 'healthy food outlets'[33]. Previous work in NYC has shown that higher access to healthy food outlets is associated with lower BMI and obesity[33,34].

Multilevel models were estimated with individual characteristics of survey respondents treated as the level 1 variables and zip code characteristics treated as level 2 variables. Statistical analyses of the cross-sectional data were performed using HLM 6, called from the Stata statistical software package version 11. Multilevel logistic regression models were estimated to predict the odds that an individual consumed five or more servings of fruit and vegetables in the previous day. All multilevel models also included a random intercept for each zip code, and adjusted for zip code-level sampling weights and survey year. Gender, age, race/ethnicity, marital status and an indicator variable for the presence of children under 18 years of age in the household were individual-level variables thought to potentially act as confounders and were included in all models. Initial analyses were conducted in the overall sample and then stratified by sex.

To investigate the role of neighbourhood poverty in modifying the relationship between individual-level SES and consumption of fruit and vegetables, separate analyses were conducted for those living in low- and high-poverty zip codes. Zip codes with a poverty rate above the median (18·8 % in our sample) were classified as high poverty; the balance was classified as low poverty. A formal test of whether associations between individual-level SES indicators and fruit and vegetable consumption varied by zip code-level poverty status (low poverty *v.* high poverty) was obtained from an interaction model which included: an ordered categorical variable for the ratio of personal income to poverty level and an ordered categorical variable for educational attainment; an indicator variable for residence in a high- *v.* low-poverty zip code; and interaction terms for each of the two ordered categorical individual-level SES variables and residence in high- *v.* low-poverty zip codes. The interaction model also included covariates for the potential confounders described above, and was run for the overall sample and for men and women separately. The *P* values from the interaction terms were used to test whether the estimated increase in odds of eating five or more servings of fruit and vegetables daily per unit change in the categorical predictor variables differed by zip code-level poverty status.

Additional analyses were conducted to determine whether the density of healthy food outlets was associated with consumption of fruit and vegetables and whether the density of healthy food outlets explained interactions between individual-level SES indicators and zip code-level poverty status. The density of healthy food outlets was categorized using quartile cut-off points from the overall distribution across zip codes.

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Columbia University Medical Center Institutional Review Board. Verbal informed consent was obtained from all participants for the CHS telephone survey.

Results

Overall, 15 634 (81 %) of those surveyed provided complete data for all covariates and the fruit and vegetable consumption question and provided residential zip code information (see Table 1 for descriptive statistics and bivariate analyses). The proportion of respondents reporting eating ≥5 servings of fruits and vegetables/d was quite low – only 10·8 % of women and 8·6 % of men did so.

Table 2 gives results from a multilevel model applied to the full sample and to men and women separately. These results showed that individual characteristics that are associated with disadvantage – low income, low education and minority status – were all strongly predictive of reduced fruit and vegetable consumption. The trend of increasing OR for consumption of ≥5 servings of fruit and vegetables/d across categories of income was quite pronounced in females. In men there was not a pronounced trend; however, compared with those in the lowest income group, those in the top income tier were significantly more likely to consume ≥5 servings of fruit and vegetables/d. The association between educational attainment and consumption of ≥5 servings of fruit and vegetables/d was similar in men and women. Overall, none of the zip code-level sociodemographic variables were associated with consumption of fruits and vegetables.

Table 3 presents results for the association between consumption of ≥5 servings of fruit and vegetables/d and individual-level income and education, estimated separately for those living in low- and high-poverty zip codes. The goal of this stratification was to assess whether neighbourhood context modified the association between individual-level measures of SES and consumption of ≥5 servings of fruit and vegetables/d. Among women, increasing income categories were associated with higher odds of consumption of ≥5 servings of fruit and vegetables/d only for those living in low-poverty zip codes; however, the formal test of interaction between individual-level income and zip code poverty did not reach statistical significance. A similar trend of increasing odds across categories of education was observed among women, which was significantly stronger for those living in low- *v.* high-poverty zip codes. Among men, associations between income and consumption of ≥5 servings of fruit and vegetables/d were similar in low- and high-poverty zip codes; however, higher educational attainment predicted consumption only for those living in high-poverty zip codes, although the formal test of interaction between individual education and zip code poverty did not reach statistical significance.

Table 4 presents the association of produce consumption with individual-level income and education and zip code-level density of healthy food outlets, overall and with stratification by gender and zip code poverty. The goal of these analyses was to determine whether zip code-level access to retail outlets selling healthier foods predicted fruit and vegetable consumption and reduced the associations between fruit and vegetable consumption and individual-level income and education. The results showed that increasing quartiles of healthy food outlet density were not associated with produce consumption in the full sample or in analyses stratified by gender and zip code-level poverty status. Comparing results in Table 4 with those in Table 3, adjustment for access to retail outlets selling healthy foods did not appear to alter the associations between personal income and produce consumption or between education and produce consumption, and did not diminish differences in OR by strata of low *v.* high zip code poverty.

In sensitivity analyses components of the healthy food outlets measure, the density of supermarkets and the density of fruit and vegetable markets, did not predict fruit and vegetable consumption. Analyses of the fruit and vegetable consumption as a continuous variable produced results consistent with those presented here.

Discussion

Self-report of consumption of five or more servings of fruits and vegetables in the past day is relatively uncommon

Table 1 Survey respondents' demographic characteristics and bivariate associations with consumption of ≥5 servings of fruit and vegetables/d: 2002 and 2004 Community Health Survey, New York City, USA

	Full sample (*n* 19 252)			Females (*n* 11 452)			Males (*n* 7800)		
		Bivariate analyses			Bivariate analyses			Bivariate analyses	
Variable	%	OR	95 % CI	%	OR	95 % CI	%	OR	95 % CI
Consume ≥5 servings of fruit and vegetables/d									
Yes	9·5			10·3			8·3		
No	86·5			85·9			87·5		
Missing	4·0			3·8			4·2		
Gender									
Male	40·5	1·00	–						
Female	59·5	1·36	1·18, 1·57						
Missing	0								
Race/ethnicity									
Hispanic	25·7	1·00	–	27·3	1·00	–	23·4	1·00	–
White	41·1	3·12	2·56, 3·81	38·5	3·92	3·03, 5·07	45·0	2·36	1·67, 3·33
African American	24·1	1·32	1·05, 1·67	26·2	1·60	1·20, 2·14	21·0	1·00	0·64, 1·58
Asian	6·5	1·52	1·06, 2·18	5·4	1·91	1·16, 3·16	8·1	1·22	0·69, 2·14
Other race/ethnicity	2·6	2·23	1·31, 3·80	2·6	2·48	1·38, 4·47	2·5	1·97	0·98, 3·96
Missing	0			0			0		
Age group									
18–24 years	9·5	1·00	–	8·9	1·00	–	10·3	1·00	–
25–44 years	41·5	0·90	0·70, 1·16	40·8	1·22	0·87, 1·72	42·4	0·65	0·45, 0·96
45–64 years	29·8	1·14	0·88, 1·48	29·5	1·65	1·17, 2·32	30·3	0·73	0·48, 1·12
65+ years	17·6	1·12	0·86, 1·46	18·9	1·54	1·06, 2·24	15·9	0·75	0·51, 1·11
Missing	1·6			1·9			1·1		
Income to poverty ratio									
Below poverty line	13·1	1·00	–	14·2	1·00	–	11·5	1·00	–
100–199 % of poverty line	18·1	1·37	1·02, 1·84	19·0	1·44	1·01, 2·04	16·8	1·29	0·79, 2·10
200–399 % of poverty line	22·2	1·82	1·34, 2·46	22·2	2·03	1·43, 2·87	22·0	1·57	1·00, 2·48
400–599 % of poverty line	14·5	2·32	1·74, 3·09	13·6	2·95	2·08, 4·19	15·8	1·72	1·14, 2·56
Above 600 % of poverty line	17·4	3·46	2·62, 4·57	14·6	4·60	3·35, 6·31	21·6	2·54	1·68, 3·85
Missing	14·7			16·4			12·3		
Education									
Less than high school	16·5	1·00	–	17·8	1·00	–	14·6	1·00	–
High-school graduate	25·2	1·50	1·09, 2·06	26·1	1·58	1·08, 2·29	23·9	1·40	0·80, 2·45
Some college	21·5	2·56	1·84, 3·57	21·6	2·79	1·93, 4·05	21·2	2·25	1·31, 3·86
College graduate	35·8	3·83	2·84, 5·16	33·5	4·24	2·95, 6·10	39·3	3·38	2·14, 5·34
Missing	1·0			1·0			1·0		
Marital status									
Not married	62·5	1·00	–	67·5	1·00	–	55·3	1·00	–
Married	36·5	1·10	0·96, 1·27	31·5	1·33	1·11, 1·61	43·8	0·90	0·73, 1·11
Missing	1·0			1·0			0·9		
Survey year									
2004	49·8	1·00	–	50·4	1·00	–	51·1	1·00	–
2002	50·2	0·90	0·78, 1·05	49·6	0·86	0·72, 1·02	48·9	0·98	0·77, 1·24
Missing	0			0			0		
Any children under 18 years of age in the household									
No	61·8	1·00	–	58·3	1·00	–	67·9	1·00	–
Yes	37·8	0·58	050, 0·68	41·7	0·52	0·43, 0·62	32·1	0·65	0·50, 0·83
Missing	0·4			0·4			0·4		

in NYC, with only 10 % of study participants reaching this threshold. By way of reference, the national average in 2002 was 29·3 % for women and 20·2 % for men[35]. Furthermore, strong disparities were observed in the prevalence of fruit and vegetable consumption by individual-level income and educational attainment. Among women the trend of increasing fruit and vegetable consumption with increasing educational attainment was significantly stronger for those living in low- compared with high-poverty zip codes. However, zip code-level access to healthy food outlets was not associated with fruit and vegetable consumption in the previous day, did not explain associations between individual-level SES and diet, and did not explain interactions between educational attainment and zip code-level poverty status observed among women.

The finding of associations between individual-level SES and produce consumption is consistent with prior work. Using data from the National Health and Nutrition Examination Survey (NHANES), Casagrande and colleagues showed that individuals with higher income and more education were substantially more likely to meet US Department of Agriculture guidelines for fruit and vegetable consumption[9]. Two prior studies have utilized multilevel analyses to consider both individual- and neighbourhood-level indicators of SES as predictors of

Table 2 Results of multilevel regression analyses of sociodemographic characteristics and consumption of ≥5 servings of fruit and vegetables/d: 2002 and 2004 Community Health Survey, New York City, USA

	Full sample		Females only		Males only	
	OR†	95 % CI	OR†	95 % CI	OR†	95 % CI
Sex						
Male	1·00	–		–		–
Female	1·48	1·32, 1·65		–		–
Race/ethnicity						
Hispanic	1·00	–	1·00	–	1·00	–
Non-Hispanic white	1·82	1·50, 2·21	1·94	1·51, 2·49	1·71	1·25, 2·33
Non-Hispanic black	1·16	0·93, 1·45	1·36	1·02, 1·81	1·00	0·70, 1·44
Asian	1·11	0·85, 1·42	1·19	0·85, 1·67	0·96	0·65, 1·43
Other	1·80	1·30, 2·48	1·89	1·24, 2·87	1·90	1·14, 3·16
Age group						
18–24 years	1·00	–	1·00	–	1·00	–
25–44 years	0·72	0·60, 0·87	1·00	0·78, 1·29	0·49	0·37, 0·65
45–64 years	0·86	0·70, 1·04	1·26	0·97, 1·64	0·54	0·40, 0·74
65+ years	0·83	0·66, 1·04	1·25	0·93, 1·68	0·53	0·36, 0·77
Income to poverty ratio						
Below poverty line	1·00	–	1·00	–	1·00	–
100–199 % of poverty line	1·23	0·98, 1·54	1·25	0·95, 1·67	1·16	0·81, 1·67
200–399 % of poverty line	1·41	1·13, 1·75	1·52	1·15, 2·01	1·20	0·84, 1·73
400–599 % of poverty line	1·41	1·12, 1·78	1·64	1·23, 2·20	1·11	0·75, 1·63
Above 600 % of poverty line	1·80	1·43, 2·27	2·11	1·57, 2·83	1·42	0·98, 2·07
Education						
Less than high school	1·00	–	1·00	–	1·00	–
High-school graduate	1·19	0·92, 1·52	1·12	0·82, 1·55	1·23	0·83, 1·85
Some college	1·90	1·49, 2·42	1·95	1·43, 2·66	1·90	1·28, 2·81
College graduate	2·23	1·75, 2·84	2·11	1·55, 2·87	2·56	1·73, 3·78
Marital status						
Unmarried	1·00	–	1·00	–	1·00	–
Married	1·17	1·03, 1·32	1·30	1·12, 1·51	1·06	0·86, 1·31
Survey year						
2004	1·00	–	1·00	–	1·00	–
2002	0·85	0·76, 0·95	0·80	0·69, 0·92	0·93	0·78, 1·12
Any children under 18 years of age in the household						
No	1·00	–	1·00	–	1·00	–
Yes	0·73	0·64, 0·84	0·72	0·61, 0·85	0·77	0·62, 0·97
Zip code-level variables						
Poverty rate						
Below the median	1·00	–	1·00	–	1·00	–
At or above median	0·89	0·75, 1·07	1·00	0·80, 1·26	0·77	0·59, 1·00
Proportion black	0·76	0·54, 1·06	0·72	0·47, 1·11	0·80	0·47, 1·35
Proportion Hispanic	0·70	0·44, 1·12	0·63	0·35, 1·16	0·84	0·43, 1·65

†OR mutually adjusted for all the predictor variables in the table.

fruit and vegetable consumption. Using NHANES III data, Dubowitz and colleagues found in a multilevel model that Census tract-level SES and individual-level education and family income were each positively associated with fruit and vegetable consumption[10]. A study of women living in suburban Melbourne, Australia found that associations between education and fruit and vegetable consumption persisted after controlling for individual- and neighbourhood-level factors[36]. In particular, they found that the neighbourhood-level food environment, measured by the density of stores selling fruit and vegetables, did not predict fruit and vegetable consumption or explain the education gradient in consumption[36]. A subsequent analysis of these data showed that neighbourhood-level disadvantage was associated with lower consumption of vegetables, but that variation in the neighbourhood food environment did not account for this association[26]. In our analyses, high zip code-level poverty did not predict fruit and vegetable consumption after control for indicators of individual SES.

Research has also examined associations between the food environment and consumption of a healthy diet, with most but not all studies finding that neighbourhood-level measures of access to healthy food outlets are associated with higher consumption of fruits and vegetables[24]. However, in the current analysis, the density of healthy food outlets in the zip code of residence did not predict consumption of five servings or more of fruits and vegetables daily and did not alter the effect estimates for associations between individual SES and produce consumption. More research is needed to understand whether these inconsistent findings reflect differences in measurement and study design or true heterogeneity of effects across population or geographic context.

Analyses of interactions between individual-level SES and neighbourhood-level poverty were motivated by a

Table 3 Associations† between socio-economic status and consumption of ≥5 servings of fruit and vegetables/d in low- and high-poverty zip codes: 2002 and 2004 Community Health Survey, New York City, USA

	Full sample				Females only				Males only			
	Low-poverty zip code‡		High-poverty zip code‡		Low-poverty zip code		High-poverty zip code		Low-poverty zip code		High-poverty zip code	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Income to poverty ratio												
Below poverty line	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–
100–199 % of poverty line	1·40	0·95, 2·06	1·12	0·85, 1·48	1·56	0·96, 2·55	1·06	0·75, 1·50	1·21	0·65, 2·23	1·19	0·75, 1·87
200–399 % of poverty line	1·77	1·23, 2·57	1·17	0·88, 1·55	2·13	1·33, 3·42	1·13	0·79, 1·62	1·23	0·68, 2·21	1·19	0·75, 1·87
400–599 % of poverty line	1·72	1·18, 2·50	1·22	0·89, 1·68	2·31	1·43, 3·74	1·17	0·78, 1·76	1·02	0·55, 1·88	1·30	0·77, 2·18
Above 600 % of poverty line	2·22	1·53, 3·22	1·46	1·05, 2·03	2·92	1·81, 4·72	1·54	1·01, 2·35	1·40	0·78, 2·51	1·39	0·82, 2·36
Education												
Less than high school	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–
High-school graduate	0·87	0·58, 1·30	1·46	1·07, 2·01	1·23*	0·71, 2·14	1·11	0·75, 1·65	0·54	0·29, 1·01	2·04	1·19, 3·53
Some college	1·68	1·14, 2·46	2·02	1·47, 2·77	2·47*	1·44, 4·24	1·64	1·12, 2·43	1·08	0·61, 1·91	2·75	1·59, 4·75
College graduate	2·07	1·42, 3·01	2·20	1·59, 3·04	2·81*	1·65, 4·79	1·55	1·04, 2·31	1·55	0·89, 2·67	3·54	2·03, 6·18

*Indicates that the trend of increasing OR is statistically significantly ($P < 0·05$) larger in magnitude in low- *v.* high-poverty zip codes.
†All models adjust for race/ethnicity, age, marital status, any children under 18 years of age in the household, year of interview, and zip code-level racial and ethnic composition.
‡Low-poverty zip codes are defined as being below the median (18·76 %) of the distribution across zip codes of the percentage of the population in poverty; zip codes with a poverty rate above the median were classified as high poverty.

previous finding of interactions between individual- and zip code-level measures of SES in predicting BMI[27]. This finding could reflect the greater availability of resources for healthy living, such as supermarkets or recreational facilities, in higher-SES neighbourhoods, which allow individuals to translate their individual SES into healthy diet and physical activity behaviours. Here, we tested whether similar interactions existed in predicting fruit and vegetable consumption, and whether access to healthy food outlets explained any such interactions. Overall, the pattern of associations between individual-level SES indicators and fruit and vegetable consumption by strata of zip code-level poverty paralleled those observed for BMI, although in most cases the differences in stratum-specific results did not meet criteria for statistical significance. However for education, the association between increasing level of education and produce consumption was significantly stronger for women living in low- as opposed to high-poverty zip codes. For men, contrary to expectations, the association between education and fruit and vegetable consumption was larger in high-poverty neighbourhoods. Although it remains plausible that neighbourhood environments play a role in allowing individuals to translate socio-economic resources into healthy behaviours, the zip code-level analyses presented here do not strongly support such an interaction.

The primary strength of the current study is the large sample of individuals surveyed in a manner designed to be representative of the adult population of NYC. The Department of Health and Mental Hygiene developed the CHS to monitor the prevalence of priority health conditions and behaviours, to identify public health issues and to inform the design of health interventions and policies. The incorporation of neighbourhood-level data into the extant CHS data sets will provide new insights into the distribution and causes of diseases and health behaviours across the City. A primary limitation of the current work is the cross-sectional study design, which limits causal inference. A second limitation is the use of a large and variably sized neighbourhood area, the zip code area (median area: $3·92\,km^2$), which was the smallest spatial identifier available in the survey data. Because NYC is a pedestrian-oriented environment in which only half of all households own vehicles, smaller neighbourhood areas may provide more valid indicators of available neighbourhood resources. Prior work in NYC showing associations between neighbourhood food environments and BMI and diet used substantially smaller neighbourhood definitions, including Census tracts with a median area of $0·18\,km^2$ and 0·50-mile street network buffers with a median area of $1·2\,km^2$[25,33,34,37]. Zip code areas may represent a suboptimal spatial unit for this kind of analysis, both because of their larger size and because of boundary effects when zip code boundaries align with the street centrelines of major commercial thoroughfares where retail food outlets often cluster. A third limitation is

Table 4 Associations† between socio-economic status, density of healthy food outlets and consumption of ≥5 servings of fruit and vegetables/d: 2002 and 2004 Community Health Survey, New York City, USA

	Full sample						Females only				Males only			
	All zip codes		Low-poverty zip code‡		High-poverty zip code‡		Low-poverty zip code		High-poverty zip code		Low-poverty zip code		High-poverty zip code	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Income to poverty ratio														
Below poverty line	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–
100–199 % of poverty line	1.23	0.98, 1.54	1.41	0.96, 2.07	1.10	0.84, 1.46	1.57	0.96, 2.56	1.06	0.75, 1.50	1.22	0.66, 2.26	1.18	0.75, 1.89
200–399 % of poverty line	1.41	1.13, 1.75	1.78	1.23, 2.58	1.14	0.86, 1.52	2.13	1.33, 3.41	1.15	0.80, 1.64	1.25	0.66, 2.26	1.19	0.74, 1.89
400–599 % of poverty line	1.41	1.12, 1.78	1.72	1.18, 2.52	1.20	0.87, 1.66	2.29	1.41, 3.72	1.18	0.79, 1.77	1.05	0.57, 1.94	1.30	0.77, 2.20
Above 600 % of poverty line	1.78	1.42, 2.25	2.22	1.53, 3.22	1.42	1.02, 1.98	2.89	1.79, 4.68	1.55	1.01, 2.36	1.44	0.80, 2.59	1.38	0.81, 2.34
Education														
Less than high school	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–
High-school graduate	1.19	0.93, 1.53	0.87	0.58, 1.30	1.46	1.06, 2.00	1.22*	0.70, 2.13	1.13	0.76, 1.67	0.55	0.30, 1.01	2.03	1.18, 3.50
Some college	1.90	1.49, 2.42	1.68	1.14, 2.46	1.99	1.45, 2.74	2.47*	1.44, 4.24	1.66	1.12, 2.44	1.09	0.62, 1.93	2.72	1.57, 4.71
College graduate	2.20	1.73, 2.81	2.05	1.40, 2.99	2.15	1.56, 2.98	2.78*	1.63, 4.75	1.56	1.12, 2.44	1.53	0.88, 2.65	3.50	2.00, 6.13
Density of healthy food stores														
Quartile 1	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–	1·00	–
Quartile 2	0.94	0.74, 1.19	0.97	0.72, 1.30	0.91	0.55, 1.48	0.86	0.59, 1.25	0.62	0.35, 1.10	1.15	0.73, 1.81	1.71	0.75, 3.91
Quartile 3	1.06	0.84, 1.34	1.00	0.73, 1.38	1.02	0.64, 1.62	0.82	0.55, 1.25	0.92	0.54, 1.57	1.37	0.84, 2.23	1.46	0.66, 3.24
Quartile 4	1.12	0.90, 1.38	1.06	0.82, 1.38	1.09	0.67, 1.76	1.04	0.75, 1.44	0.89	0.51, 1.54	1.10	0.73, 1.65	1.73	0.76, 3.91

*Indicates that the trend of increasing OR is statistically significantly ($P < 0·05$) larger in magnitude in low- *v.* high-poverty zip codes.

†All models adjust additionally for race/ethnicity, age, marital status, number of children under 18 years of age in the household, year of interview, and neighbourhood race and ethnicity.

‡Low-poverty zip codes are defined as being below the median (18·76 %) of the distribution across zip codes of the percentage of the population in poverty; zip codes with a poverty rate above the median were classified as high poverty.

that the CHS is designed to provide health surveillance data on key indicators, similar to the Centers for Disease Control and Prevention's BRFSS, and does not provide in-depth measures of diet. The survey used a single question about the number of servings of fruit and vegetables consumed during the day prior to the CHS telephone interview. Finally, our measure of access to food outlets selling fruit and vegetables did not account for the specific availability or quality of produce in those settings.

Conclusion

The results show that higher individual-level SES is associated with higher odds of eating five or more servings of fruits and vegetables daily. Patterns of cross-level interactions between individual- and zip code-level measures of SES seen in prior analyses of BMI were also observed here, although most of the interaction effects did not reach statistical significance. Zip code-level disparities in access to stores selling healthy foods did not predict consumption of fruits and vegetables or explain the disparities across individual SES. These results affirm the importance of individual SES, particularly education, in healthy behaviour patterns while providing further evidence about the role of neighbourhood environments. Further studies are needed that examine additional measures of availability and quality of fruits and vegetables, and whether disparities in neighbourhood access to healthy food at smaller geographic levels are predictors of fruit and vegetable consumption.

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