Change in Obesity Prevalence among New York City Adults: the NYC Health and Nutrition Examination Survey, 2004 and 2013–2014

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Published online: 9 July 2018
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Abstract The objective of this study was to measure change in obesity prevalence among New York City (NYC) adults from 2004 to 2013–2014 and assess variation across sociodemographic subgroups. We used objectively measured height and weight data from the NYC Health and Nutrition Examination Survey to calculate relative percent change in obesity (≥ 30 kg/m²) between 2004 ($n = 1987$) and 2013–2014 ($n = 1489$) among all NYC adults and sociodemographic subgroups. We also examined changes in self-reported proxies for energy imbalance. Estimates were age-standardized and statistical significance was evaluated using two-tailed T tests and multivariable regression ($p < 0.05$). Between 2004 and 2013–2014, obesity increased from 27.5 to 32.4% ($p = 0.01$). Prevalence remained stable and high among women (31.2 to 32.8%, $p = 0.53$), but increased among men (23.4 to 32.0%, $p = 0.002$), especially among non-Latino White men and men age ≥ 65 years. Black adults had the highest prevalence in 2013–2014 (37.1%) and Asian adults experienced the largest increase (20.1 to 29.2%, $p = 0.06$),

especially Asian women. Foreign-born participants and participants lacking health insurance also had large increases in obesity. We observed increases in eating out and screen time over time and no improvements in physical activity. Our findings show increases in obesity in NYC in the past decade, with important sociodemographic differences.

Keywords Obesity · Disparities · Trends · Physical activity · Diet · Surveillance

Introduction

In the USA, the prevalence of obesity among adults significantly increased from 25.3% in 1976–1980 to 33.2% in 2003–2004 [1–4], with meaningful differences by race/ethnicity and gender and especially large increases among non-Latino Black women [5]. Later findings from the National Health and Nutrition Examination Survey (NHANES) revealed that between 2005 and 2014, the prevalence of obesity continued to increase for women only, regardless of race/ethnicity, but remained stable for men [2]. As obesity is linked to adverse health outcomes, including hypertension, diabetes, heart disease, stroke, and cancer [2, 6, 7], monitoring obesity is critical in shaping national and local prevention strategies [8].

The risk factors for obesity are multi-factorial and likely involve an interplay of genetics, environmental factors, social determinants, and lifestyle factors [9]. The literature suggests that several proxies for energy

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imbalance—such as sedentary behavior, inadequate physical activity, low fruit and vegetable intake, high eating out frequency, and excess total energy intake—may be linked to obesity [10–14], but results are highly mixed and inconsistent [15, 16]. Results from analyses of NHANES data have shown improvements in some of these indicators and worsening in others. For example, diet quality score (i.e., a diet pattern where higher score predicts lower cardiovascular disease risk) increased slightly and mean energy intake decreased between 1999 and 2012 [17–19], yet sedentary behaviors and the proportion of adults reporting no leisure-time physical activity increased [20]. In contrast, intake of total fruits and vegetables did not significantly change over this time period, and improvements in self-reported diet behaviors and leisure-time physical activity were not observed for racial and ethnic subgroups (e.g., non-Latino Black and Mexican American adults) [17]. These findings underscore the importance of collecting surveillance data, which can be used to track multiple components of obesity risk, including diet, physical activity, and sedentary behaviors.

National trends in obesity and associated risk factors are carefully tracked by population-based health surveys using objective measures, such as NHANES, but most state and local jurisdictions have limited data to monitor change over time, at best having self-reported height and weight data from telephone surveys. In New York City (NYC), a number of major initiatives to improve population health surveillance of chronic diseases and risk factors were launched in the past decade, with an aim to guide decision-making and evaluate progress achieved. As part of its monitoring and surveillance portfolio, the NYC Health Department launched the New York City Health and Nutrition Examination Survey (NYC HANES) in 2004, a population-based interview and physical exam survey with similar methods, labs, and standards as NHANES. In 2013–2014, a second NYC HANES was performed as an academic-government partnership, providing an opportunity to examine objectively measured changes in obesity prevalence at the municipal level in the context of local initiatives. During this time interval, a number of policies, programs, and educational campaigns were implemented in NYC to promote healthy living. Examples include calorie labeling in chain restaurants, zoning and tax incentives for supermarket creation and expansion (i.e., FRESH program), NYC Agency Food Standards, improvements in cycling infrastructure [21], the Shape Up NYC fitness

program [22], and the increase in the number of farmer's markets accepting Health Bucks [23].

Here, we describe changes in prevalence of obesity in NYC adults from 2004 to 2013–2014 using objective measures of height and weight collected from the NYC HANES survey. We examined changes in the distribution of obesity, BMI, and diet, physical activity, and screen time behaviors in NYC adults over the past 10 years, during which several interventions to support healthy living were implemented. We compared changes in obesity prevalence in NYC to corresponding changes at the national level using data from NHANES 2003–2004 and 2011–2012. We also examined local and national changes in obesity prevalence and physical activity behaviors within gender and racial/ethnic subgroups.

Methods

Study Sample

We used data from NYC HANES, a population-based, cross-sectional survey of non-institutionalized adult NYC residents (aged 20 years or older) [24, 25]. A three-stage cluster household sampling plan was used to obtain representative citywide estimates of health status indicators, including body mass index (BMI) and diet and physical activity behaviors. Data collection for study participants consisted of three components: a two-part interview, a brief physical examination, and a biologic specimen collection. Overall response rates were 55% ($n = 1999$) and 36% ($n = 1527$) in 2004 and 2013–2014, respectively. Participants with valid height and weight measurements were included in the current study, for final sample sizes of 1987 and 1489 in 2004 and 2013–2014, respectively. More information on survey design, study population, and quality of NYC HANES are published elsewhere [24, 25].

To obtain national estimates of obesity change, we used data from NHANES 2003–2004 and 2011–2012 [26], with a sample size of 10,927 and 7408, respectively, after excluding those without valid height and weight measurements. Comparison of estimates allows us to compare local progress to national secular change in population prevalence of obesity, which can inform policymakers as they tailor their public health strategies.

Outcome Variable

We calculated our outcome variable of obesity (≥ 30 kg/m²) using height and weight measurements from the physical examination. Based on World Health Organization's recommendations [27], we used a modified cut-off point of ≥ 27.5 kg/m² to categorize obesity for Asian participants. Trained staff collected weight to the nearest 0.1 kg and height to the nearest 0.5 cm, using protocols adapted from the NHANES Medical Examination Component manuals [28].

Covariates and Secondary Outcomes

Sociodemographic characteristics included age, gender, race/ethnicity, foreign-born status, duration of residence in the USA, education (less than high school, high school, some college, college degree, or more), neighborhood poverty level of census tract (0–< 10%, 10–< 20%, 20–< 30%, and 30–100% of population living below the federal poverty line in a census tract), health insurance status, and having a primary care provider.

To capture potential changes in consumption of high-calorie foods away from home and intake of low-calorie, nutrient-dense foods, we included self-reported weekly frequency of eating meals that were prepared in a restaurant and weekly intake of fruits and vegetables (times per day) as proxies for diet quality. Total screen time was calculated using responses to questions about how much time the participant spent sitting and watching TV or videos or using a computer outside of work. Using Healthy People 2020, participants were defined as physically active if they reported 150 min of moderate physical activity or 75 min of vigorous physical activity or 150 min of a combination of moderate and vigorous physical activity a week in at least 10 min episodes [29]. All questions related to covariates and secondary outcomes were identical across survey years.

Statistical Analysis

To account for the complex sampling design and non-response, we statistically weighted all analyses, re-adjusting weights to account for missing height and weight values; thus, estimates are representative of the NYC population. We calculated the relative percent change in primary and secondary outcome variables by dividing the observed change in values between survey years (2013–2014 and 2004) by the baseline

value (2004), and statistical significance of change was tested using a *T* test with a two-tailed *p* value < 0.05. Prevalence estimates were age-standardized to the 2000 US population. The primary outcome variable (obesity) was stratified by gender, age, and racial/ethnic subgroups. We also calculated change in obesity prevalence among foreign-born participants by duration of residence and health insurance status. We examined changes in secondary behavioral outcomes in the overall NYC adult population and by gender and obesity status. We flagged as imprecise and potentially unreliable any estimates with relative standard errors greater than 30%, 95% confidence interval half-widths greater than 10, or sample denominators less than 50. We used the “proc descriptive” statement and the “t_pct” option in SAS 9.4 (SAS Institute Inc., Cary, NC) and SUDAAN version 9.0 (Research Triangle Institute, Research Triangle Park, NC).

In sensitivity analyses, we calculated the relative percent change in obesity without using the modified cut-off point for Asian participants; and we calculated the percent change in physical activity behavior using guidelines from Healthy People 2010, which have stricter criteria for classifying individuals as meeting physical activity recommendations than current guidelines [30]. To determine whether the distribution of BMI in our samples shifted between survey years, we also plotted BMI values at 2004 and 2013–2014 using non-parametric density curves.

To explore whether sociodemographic characteristics and behaviors explained secular changes in obesity prevalence, we constructed two log-binomial regression models to examine the differential magnitude in association between obesity prevalence and survey year, with models either adjusting for (1) age, racial/ethnic origin, foreign-born status, and education, or (2) age, diet, physical activity, and screen time behaviors. The potential for interaction between gender and other variables was assessed but interaction terms lacked statistical significance and were excluded from the final model. We used a change-in-estimate approach to determine the extent to which including these variables in our model accounted for the observed secular change across the two time periods; specifically, we evaluated the magnitude with which inclusion of sociodemographic or behavioral variables in the model changed the survey year beta estimate greater than 10% relative to a crude model [31].

To compare changes in local and national estimates, we calculated the relative percent change in primary outcome variables between NHANES survey years 2011–2014 and 2001–2004 (the modified cut-off point for Asian participants in NYC HANES was not used to be consistent with NHANES), and tested statistical significance of change using a *T* test with a two-tailed *p* value < 0.05 . We also compared the relative percent change in leisure-time physical activity using both data sources. However, we acknowledge that a new physical activity questionnaire was introduced in NHANES 2007–2008, so estimates of change at the national level should be interpreted with caution (NYC HANES physical activity questions match baseline NHANES physical activity questions).

Results

Between 2004 and 2013–2014, the age-standardized prevalence of obesity in the NYC adult population increased significantly, from 27.5 to 32.4% ($p = 0.01$) (Table 1). Overall, the distribution of BMI values in the general adult population shifted towards higher values by 2013–2014 (Fig. 1). Prevalence of obesity remained stable and high among women (31.2% in 2004 and 32.8% in 2013–2014, $p = 0.53$), while we observed a statistically significant increase among men (23.4% in 2004 and 32.0% in 2013–14; $p = 0.002$). Non-Latino White adults had the lowest prevalence of obesity in 2013–2014 (27.8%), while non-Latino Black adults had the highest prevalence of obesity (37.1%). Relative to other racial/ethnic groups, Asian adults experienced the largest increase in obesity over time (20.1 to 29.2%, $p = 0.06$), although changes over time by race/ethnicity were not statistically significant.

In subgroup analyses, observed increases among men were largely concentrated in non-Latino White men, with a 61.6% increase between survey years ($p = 0.01$). We also observed a statistically significant increase among Asian women (19.8 to 32.7%; $p = 0.03$). The magnitude and direction of changes were consistent with and without using the modified obesity cut-off point for Asian participants (data not shown). The prevalence of obesity also increased among men age 65 years and older (25.9 to 41.3%; $p = 0.04$), though the precision is limited due to small sample size.

Increases in obesity prevalence were greatest among adults with no health insurance and among foreign-born

participants. The change in obesity among foreign-born participants who were uninsured (20.0 to 33.7%, $p = 0.02$) was more than twice the increase among foreign-born participants who were insured (24.3 to 31.9%, $p = 0.02$) (data not shown). We also observed a statistically significant increase in obesity prevalence among those residing in the USA for more than 10 years (26.6 to 34.3%; $p = 0.03$), but not among those residing in the USA for 10 or fewer years (19.3 to 27.4%; $p = 0.15$). We did not observe meaningful differences in obesity across levels of neighborhood poverty or educational attainment over time.

We observed several meaningful changes in proxies for energy imbalance among NYC adults over time, including dietary behaviors, physical activity, and screen time (Table 2). Between 2004 and 2013–2014, the level of self-reported weekly intake of fruits and vegetables decreased by 28.2% for fruits ($p < 0.001$) and 27.7% for vegetables ($p < 0.001$). The weekly frequency of eating out increased from a citywide average of 2.7 meals per week in 2004 to 3.8 meals per week in 2013–2014 (40.7%; $p < 0.001$).

Using Healthy People 2020 guidelines, we did not observe any meaningful changes in the percentage of adults meeting physical activity recommendations ($p = 0.71$) or the percentage of adults reporting no leisure-time physical activity ($p = 0.52$). The percentage of NYC adults reporting screen time of 3 or more hours per day increased by 32.3% ($p < 0.001$). Secular changes in diet, physical activity, and screen time were comparable in magnitude between obese adults and non-obese adults (Appendix Table 4).

Adjustment for age, gender, race/ethnicity, foreign-born status, and educational attainment [$\beta = 0.15$ (SE = 0.06)] did not meaningfully lower the magnitude of the observed shift in obesity prevalence between survey years, when compared to a model adjusting for age only [$\beta = 0.17$ (SE = 0.06)]. However, adjusting for age, diet, physical activity, and screen time behavior accounted for approximately 22.5% of the increase in obesity prevalence [$\beta = 0.13$ (SE = 0.07)], compared to the model adjusting for age only.

Compared to the increase in obesity prevalence among NYC adults, change in the prevalence of obesity among adults nationwide was substantially larger (31.5% increase nationally, $p < 0.001$; and 17.1% increase in NYC, $p = 0.02$) (Table 3). Nationally, the increase in obesity was greater for women (34.5%, $p < 0.001$) than men (28%, $p < 0.001$).

Table 1 Changes in prevalence of obesity among NYC adults (aged ≥ 20 years) by sociodemographic characteristics, NYC HANES 2004 and 2013–2014

Characteristic	2004					2013–2014					Change over time	
	Total sample		Obesity prevalence*			Total sample		Obesity prevalence*				
	N	%	N	%	95% CI	N	%	N	%	95% CI	Relative change in obesity	p value
Total	1987	NA	538	27.5	25.0–30.0	1489	NA	455	32.4	29.7–35.2	17.8	0.01
Age group												
20–44	1196	52.8	278	25.0	21.3–29.2	810	51.0	200	29.3	25.1–33.8	17.2	0.16
45–64	611	31.7	197	30.1	25.6–34.9	477	32.6	180	36.3	31.4–41.5	20.6	0.07
≥ 65	180	15.4	63	34.3	27.8–41.4	202	16.4	75	40.4	33.2–48	17.8	0.23
Gender												
Male	829	46.1	196	23.4	20.3–26.8	622	46.6	180	32.0	27.7–36.5	36.8	0.002
Female	1158	53.9	342	31.2	28.0–34.5	867	53.4	275	32.8	29.2–36.6	5.1	0.53
Race/ethnicity												
Non-Latino White	611	38.3	134	22.6	19.1–26.5	499	35.0	123	27.8	23.4–32.7	23.0	0.09
Non-Latino Black	431	23.1	146	33.7	28.6–39.2	328	21.3	124	37.1	31.4–43.2	10.1	0.40
Latino	655	26.1	202	32.0	27.7–36.6	385	27.1	136	36.9	31.9–42.2	15.3	0.15
Asian	259	10.9	51	20.1	14.6–26.9	198	14.0	51	29.2	22.3–37.2	45.3	0.06
Education												
Less than high school	570	27.1	198	34.4	29.9–39.1	311	18.9	130	40.7	35.1–46.5	18.3	0.09
High school	382	19.1	100	25.9	21.2–31.2	231	23.1	87	36.5	29.9–43.6	40.9	0.01
Some college	416	20.5	109	27.8	23.2–33.1	329	22.7	111	34.8	29.4–40.7	25.2	0.07
College degree or more	612	33.3	128	21.9	17.9–26.6	616	35.3	127	24.0	20.0–28.5	9.6	0.50
Neighborhood poverty level												
0–< 10%	487	28.0	105	22.5	18.1–26.9	399	27.6	109	29.9	24.3–36.2	32.3	0.06
10–< 20%	569	32.4	133	24.3	19.8–28.7	502	32.4	149	32.1	27.3–37.3	31.6	0.03
20–< 30%	273	12.6	86	33.4	25.9–40.8	324	21.2	89	28.1	23.8–32.8	–16.4	0.21
30–100%	658	27.0	214	32.6	28.3–36.8	264	18.8	108	41.4	35.5–47.6	22.1	0.05
Country of birth												
US born	967	51.2	299	31.3	27.7–35.2	831	54.0	247	32.9	29.4–36.6	5.1	0.57
Non-US born	1014	48.8	237	23.4	20.4–26.7	651	46.0	205	31.6	27.3–36.2	35.0	0.002
Health insurance												
Has health insurance	1507	79.2	428	28.6	25.8–31.6	1240	83.0	390	33.1	30.2–36	15.7	0.04
No health insurance	464	20.8	107	21.6	17.0–27.1	246	17.0	64	33.4	26–41.7	54.6	0.01
Have a primary care provider												
Yes	1488	78.1	436	29.1	26.4–32.0	1218	81.8	398	33.7	30.7–36.9	15.8	0.04
No	483	21.9	101	21.5	16.4–27.8	270	18.2	57	26.6	19.9–34.6	23.7	0.29
BMI												
< 25	794	38.6	NA	NA	NA	558	35.2	NA	NA	NA	NA	NA
25–29	682	35.4	NA	NA	NA	500	34.4	NA	NA	NA	NA	NA
≥ 30	511	26.1	NA	NA	NA	431	30.4	NA	NA	NA	NA	NA
Non-Latina White, female	321	18.7	76	25.1	20.2–30.7	268	17.1	56	23.4	18.5–29	–6.8	0.67
Non-Latino White, male	290	19.6	58	19.8	15.3–25.4	231	17.9	67	32.0	25–39.9	61.6	0.01
Black, female	269	13.4	109	40.3	34.1–47.0	208	12.5	86	40.0	32.2–48.4	–0.7	0.95

Table 1 (continued)

Characteristic	2004					2013–2014					Change over time	
	Total sample		Obesity prevalence*			Total sample		Obesity prevalence*				
	<i>N</i>	%	<i>N</i>	%	95% CI	<i>N</i>	%	<i>N</i>	%	95% CI	Relative change in obesity	<i>p</i> value
Black, male	162	9.8	37	24.4	18.2–32.0	120	8.7	38	33.0	24.1–43.4	35.2	0.16
Latina, female	406	15.3	129	33.9	28.4–40.0	231	15.0	85	37.8	31–45.2	11.5	0.39
Latino, male	249	10.9	73	30.1	23.5–37.6	154	12.2	51	35.5	27.4–44.4	17.9	0.34
Asian, female	145	5.7	26	19.8	13.1–28.8	117	7.5	33	32.7	24.6–41.9	65.2	0.03
Asian, male	114	5.2	25	20.5	13.3–30.3	81	6.5	18	24.1 [†]	13.6–38.9	17.6	0.65

BMI, body mass index (kg/m^2)

*All estimates were age-standardized to the 2000 US population

[†] Estimate should be interpreted with caution as relative standard error was greater than 30%, 95% confidence interval half-width was greater than 10, or sample denominator was less than 50

Discussion

Using objective measures of height and weight of participants drawn from a rigorous and representative sampling scheme, we characterized change in obesity prevalence among adults living in NYC from 2004 to 2013–2014, providing local objective information on the obesity epidemic not available in other municipalities. Overall, we found that obesity increased by 17.8% in the NYC adult population, which is sizable yet significantly smaller than national trends. With an understanding that a long-term objective is to reduce the burden of

obesity, a relatively smaller increase compared to national trends is notable. Our findings are also consistent with self-reported changes from the NYC Community Health Survey (CHS), a cross-sectional telephone survey of behavioral risk factors and chronic disease, with an annual sample of approximately 10,000 randomly selected adults aged 18 and older from all five boroughs of New York City. The survey results indicated that the prevalence of obesity increased from 21.7% in 2004 to 24.7% in 2014 ($p < 0.001$) [28]. Although absolute values for obesity prevalence were lower in NYC CHS compared to NYC HANES data, previous work has

Fig. 1 Distribution of BMI (kg/m^2) in NYC HANES 2004 and 2013–2014

Table 2 Changes in obesity risk factors (mean/%) among (a) all NYC adults, (b) obese NYC adults, and (c) non-obese NYC adults (aged 20 years and older), NYC HANES 2004 and 2013–2014.

	2004		2013–2014			
	<i>N</i>	%/mean	<i>N</i>	%/mean	% change	<i>p</i> value
(a) All NYC adults						
Physical activity						
Recommended physical activity	785	43.1	585	42.4	− 1.6	0.71
Some physical activity	459	26.0	377	25.4	− 2.3	0.72
No physical activity	516	30.9	439	32.2	4.2	0.52
Diet [^]						
Weekly eating out frequency	1972	2.7	1486	3.8	40.7	< 0.001
Weekly vegetable intake	1971	13.7	1488	9.9	− 27.7	< 0.001
Weekly fruit intake	1971	7.8	1488	5.6	− 28.2	< 0.001
Screen time (total)						
≥ 3 h/day	933	48	946	63.5	32.3	< 0.001
0–< 3 h/day	1039	52	543	36.5	− 29.8	< 0.001
(b) Obese NYC adults						
Physical activity						
Recommended physical activity	198	41.6	155	39.7	− 4.6	0.61
Some physical activity	124	26.3	105	22.1	− 16.0	0.17
No physical activity	152	32.2	166	38.3	18.9	0.09
Diet [^]						
Weekly eating out frequency	537	2.5	453	3.6	44.0	0.00
Weekly vegetable intake	536	13.1	454	9.3	− 29.0	< 0.001
Weekly fruit intake	536	8.3	454	5	− 39.8	< 0.001
Screen time (total)						
≥ 3 h/day	286	53.8	311	67.1	24.7	< 0.001
0–< 3 h/day	251	46.2	144	32.9	− 28.8	< 0.001
(c) Non-obese NYC adults						
Physical activity						
Recommended physical activity	587	43.7	430	44.4	1.6	0.77
Some physical activity	335	26.0	272	26.5	1.9	0.83
No physical activity	364	30.3	273	29.2	− 3.6	0.63
Diet [^]						
Weekly eating out frequency	1435	2.7	1033	3.9	44.4	< 0.001
Weekly vegetable intake	1435	13.9	1034	10.3	− 25.9	< 0.001
Weekly fruit intake	1435	7.8	1034	5.9	− 24.4	< 0.001
Screen time (total)						
≥ 3 h/day	647	46	635	61.6	33.9	< 0.001
0–< 3 h/day	788	54	399	38.4	− 28.9	< 0.001

*All estimates were standardized to the 2000 US population

[^]Diet questions were analyzed as continuous variables

shown that BMI from self-reported measures is systematically lower than BMI from objective height and weight measures [32].

In NYC, we observed increases in obesity for men but not in women, a finding that is inconsistent with the recent national pattern of increased obesity prevalence

Table 3 Changes in obesity prevalence and physical activity behavior among all US and NYC adults (aged 20 years and older), NHANES 2003–2004 and 2011–2012 and NYC HANES 2004 and 2013–2014

	NYC HANES						NHANES					
	2004		2013–2014		Change		2001–2004		2011–2014		Change	
	<i>N</i>	%	<i>N</i>	%	%	<i>p</i> value	<i>N</i>	%	<i>N</i>	%	%	<i>p</i> value
Total population												
Total obesity prevalence*	511	26.3	431	30.8	17.1%	0.02	4852	27.6	3956	36.3	31.5%	<0.001
Physical activity												
Recommended physical activity	785	43.1	585	42.4	−1.6%	0.71	9500	62.8	3568	37.5	−40.3%	<0.001
Some physical activity	459	26.0	377	25.4	−2.3%	0.72	2957	18.3	1738	17.0	−7.1%	0.1578
No physical activity	516	30.9	439	32.2	4.2%	0.52	3932	18.9	5425	45.5	140.7%	<0.001
Female												
Total obesity prevalence*	330	30.3	261	31.2	3.0%	0.73	2577	28.4	2261	38.2	34.5%	<0.001
Physical activity												
Recommended physical activity	419	39.3	289	35.6	−9.4	0.14	4379	58.3	1619	34.2	−41.3%	<0.001
Some physical activity	284	27.0	225	26.2	−3.0	0.72	1668	20.9	987	18.6	−11.0%	0.043
No physical activity	319	33.7	300	38.2	13.4	0.08	2170	20.8	2921	47.3	127.4%	<0.001
Male												
Total obesity prevalence*	181	21.9	170	30.2	37.9%	0.00	2275	26.8	1695	34.3	28.0%	<0.001
Physical activity												
Recommended physical activity	366	47.4	296	50.2	5.9	0.35	5121	67.2	1949	41.1	−38.8%	<0.001
Some physical activity	175	24.9	152	24.5	−1.6	0.89	1289	15.7	751	15.4	−1.9%	0.781
No physical activity	197	27.8	139	25.3	−9.0	0.40	1762	17.0	2504	43.5	155.9%	<0.001

All estimates were standardized to the 2000 US population

*Asian specific cutoffs were not used in this table for the purpose of comparison with NHANES

among women only [2, 33]. We also observed a meaningful increase in obesity among older men, which is corroborated by recent national estimates; however, small sample size limited our ability to confirm the magnitude of change with precision [34]. Relative changes in the diet and physical activity behaviors examined in this paper do not explain the local gender differences between men and women, though differences in other unmeasured factors—such as total energy intake, diet quality, or body composition—may be responsible for the discrepancy. Consistent with national estimates and other studies, Black women in NYC had the highest prevalence of obesity [2, 35]. We also observed increases in obesity among Asian women, a group with a historically low prevalence of obesity. Our findings highlight the potential need to tailor interventions for specific demographic subgroups.

In addition to changes in obesity prevalence, our findings show that consumption of fruits and vegetables

and frequency of eating out worsened among NYC adults, and sedentary behaviors such as hours spent using a computer and watching TV increased; while, physical activity behavior did not change meaningfully. Further, results from the log-binomial regression model suggest that these proxies for energy balance partially explain the increase in obesity between exam years. Though we lacked data related to total energy intake and additional food groups, these findings may indicate that potentially important changes in energy balance (increases in calories consumed and increases in sedentary behaviors) may have contributed to increases in obesity in NYC over time [11, 15, 36].

We found that the prevalence of obesity increased by 35.0% for foreign-born adults, and that this increase was largely driven by those residing in the USA for 10 or more years. This is consistent with literature showing that increasing duration of residence in the USA is linked to higher BMI [37]. We also found that the

prevalence of obesity increased by 57.4% for those with no health insurance, and a 68.5% increase in obesity for foreign-born adults lacking health insurance (who are more likely to lack health insurance in our sample). This finding is disconcerting because a lack of health insurance could lead to poor management of obesity complications and co-morbidities (e.g., diabetes) among obese individuals, with a potential loss in work-related income, disability, and premature mortality [38, 39]. From this examination survey, it is difficult to determine how a lack of health insurance may impact obesity risk. While such an association may be driven by underlying socioeconomic differences, lack of health insurance might also be associated with work status and non-standard work hours, which have been shown to increase risk of non-optimal sleep, greater recreational screen time, worse dietary practices, and depression [40]. Lastly, we found that obesity change did not vary by neighborhood poverty level. While we cannot assess from the data collected in NYC HANES, one possibility is that in addition to neighborhood poverty, factors such as work hours, culture, food options, and preferences may be important.

Our study had several limitations, including the lack of longitudinal data on study participants. The cross-sectional nature of the study design does not allow us to capture individual change in weight status and obesity risk factors. Although we were able to measure changes in fruit and vegetable intake and eating out frequency at each year, we were not able to investigate changes in energy intake or potential substitution effects via consumption of other food groups and beverages. Further, direct comparisons between local and national physical activity behavior was not possible due to slight differences in physical activity survey questions. Data related to diet, physical activity, and screen time behaviors were also self-reported, potentially introducing imprecision and bias. In addition, geographic data in NHANES were not available in the public-use files, so we were not able to restrict the national sample to urban core areas and compare changes in NYC to changes in other urban areas. Despite these limitations, our study also had several strengths, including using unique, local objective data related to height and weight, allowing us to track the obesity epidemic in NYC.

Our findings show increases in the prevalence of obesity, eating out in restaurants, and sedentary behaviors, as well as decreases in fruit and vegetable consumption, among NYC adults between

2004 and 2013–2014. We observed important differences in trends by gender and race/ethnicity, with relatively larger increases in obesity among men and Asian populations. For NYC men, this rise in obesity was consistent with the national rise in obesity among men during the same time period; whereas, obesity among NYC women remained stable, while the national prevalence increased. Awareness of how obesity and diet, physical activity, and screen time behaviors are changing will assist local policy makers in tracking the impact of efforts to decrease the prevalence of obesity.

Public Health Implications

Obesity prevalence increased in NYC between 2004 and 2013–2014, but less so than observed changes in national prevalence over the same time period. We found that several populations were at greater risk, including non-Latino White men, men age ≥ 65 years older men, Asian adults, Black women, foreign-born adults, and those lacking health insurance coverage. A number of interventions to sustainably support healthy living—which can help prevent diet-related chronic disease, such as type-2 diabetes and hypertension—have been implemented in NYC over the past decade [21, 22]. Whether such efforts contributed to the slower increase in NYC cannot be discerned from these findings. Regardless, it is important to address observed increases in obesity among specific subgroups (e.g., older men, foreign-born adults, those lacking health insurance), potentially with targeted resources. Since it is difficult for adults to lose weight and maintain weight loss [41], and because a substantial proportion of the NYC population is currently obese, it may take decades before obesity prevalence decreases meaningfully.

Acknowledgments Support for NYCHANES 2013–2014 was provided by the de Beaumont Foundation with additional support from the Robert Wood Johnson Foundation, Robin Hood, the NYS Health Foundation, Quest Diagnostics, and the Doris Duke Charitable Foundation, NYC Health Department, Hunter College Office of the Provost, CUNY Vice Chancellors Office of Research, and CUNY School of Public Health Dean's Office.

Appendix

Table 4 Changes in obesity risk factors (mean/%) among (a) all NYC adults, (b) obese NYC adults, and (c) non-obese NYC adults (aged 20 years and older), by gender, NYC HANES 2004 and 2013–2014

	2004		2013–2014			
	<i>N</i>	%/mean	<i>N</i>	%/mean	% change	<i>p</i> value
(a) All NYC adults, males						
Physical activity						
Recommended physical activity	366	47.4	296	50.2	5.9	0.35
Some physical activity	175	24.9	152	24.5	−1.6	0.89
No physical activity	197	27.8	139	25.3	−9.0	0.40
Diet [^]						
Weekly eating out frequency	823	3.4	622	4	17.6	0.09
Weekly vegetable intake	822	12.4	622	9.5	−23.4	<0.001
Weekly fruit intake	822	7.1	622	5.2	−26.8	<0.001
Screen time (total)						
≥3 h/day	409	49.9	404	65	30.3	<0.001
0–<3 h/day	413	50.1	218	35	−30.1	<0.001
(b) Obese NYC adults						
Physical activity						
Recommended physical activity	82	46.8	86	51.8	10.7	0.41
Some physical activity	45	27.9	29	14.7	−47.3	0.01
No physical activity	48	25.2	53	33.4	32.5	0.13
Diet [^]						
Weekly eating out frequency	196	3.5	180	4.1	17.1	0.30
Weekly vegetable intake	195	12	180	8.6	−28.3	0.04
Weekly fruit intake	195	7.8	180	4.6	−41.0	0.00
Screen time (total)						
≥3 h/day	111	57.3	117	63.1	10.1	0.35
0–<3 h/day	85	42.7	63	36.9	−13.6	0.35
(c) Non-obese adults, males						
Physical activity						
Recommended physical activity	284	47.4	210	49.8	5.1	0.47
Some physical activity	130	24.1	123	28.6	18.7	0.15
No physical activity	149	28.5	86	21.6	−24.2	0.03
Diet [^]						
Weekly eating out frequency	627	3.4	442	3.9	14.7	0.18
Weekly vegetable intake	627	12.6	442	10	−20.6	0.00
Weekly fruit intake	627	6.9	442	5.5	−20.3	0.01
Screen time (total)						
≥3 h/day	298	47.6	287	65.8	38.2	<0.001
0–<3 h/day	328	52.4	155	34.2	−34.7	<0.001
(d) All NYC adults, females						
Physical activity						
Recommended physical activity	419	39.3	289	35.6	−9.4	0.14

Table 4 (continued)

	2004		2013–2014		% change	<i>p</i> value
	<i>N</i>	%/mean	<i>N</i>	%/mean		
Some physical activity	284	27.0	225	26.2	−3.0	0.72
No physical activity	319	33.7	300	38.2	13.4	0.08
Diet [^]						
Weekly eating out frequency	1149	2.1	864	3.7	76.2	<0.001
Weekly vegetable intake	1149	14.7	866	10.3	−29.9	<0.001
Weekly fruit intake	1149	8.5	866	5.8	−31.8	<0.001
Screen time (total)						
≥3 h/day	524	46.6	542	62.1	33.3	<0.001
0–<3 h/day	626	53.4	325	37.9	−29.0	<0.001
(e) Obese adults, females						
Physical activity						
Recommended physical activity	116	38.4	69	29.2	−24.0	0.03
Some physical activity	79	25.4	76	28.6	12.6	0.44
No physical activity	104	36.1	113	42.2	16.9	0.18
Diet [^]						
Weekly eating out frequency	341	1.8	273	3.3	83.3	0.00
Weekly vegetable intake	341	13.9	274	9.9	−28.8	<0.001
Weekly fruit intake	341	8.7	274	5.2	−40.2	<0.001
Screen time (total)						
≥3 h/day	175	51.6	194	71.1	37.8	<0.001
0–<3 h/day	166	48.4	81	28.9	−40.3	<0.001
(f) Non-obese adults, females						
Physical activity						
Recommended physical activity	303	40.4	220	39.7	−1.7	0.82
Some physical activity	205	27.5	149	24.5	−10.9	0.27
No physical activity	215	32.1	187	35.8	11.5	0.23
Diet [^]						
Weekly eating out frequency	808	2.1	591	3.9	85.7	<0.001
Weekly vegetable intake	808	15.2	592	10.5	−30.9	<0.001
Weekly fruit intake	808	8.7	592	6.1	−29.9	<0.001
Screen time (total)						
≥3 h/day	349	44.8	348	57.8	29.0	<0.001
0–<3 h/day	460	55.2	244	42.2	−23.6	<0.001

References

1. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999–2000. *JAMA*. 2002;288(14):1723–7.
2. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in obesity among adults in the United States, 2005 to 2014. *JAMA*. 2016;315(21):2284–91.
3. Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL. Increasing prevalence of overweight among US adults: the National Health and Nutrition Examination Surveys, 1960 to 1991. *JAMA*. 1994;272(3):205–11.
4. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA*. 2006;295(13):1549–55.
5. Romero CX, Romero TE, Shlay JC, Ogden LG, Dabelea D. Changing trends in the prevalence and disparities of obesity and other cardiovascular disease risk factors in three racial/ethnic groups of USA adults. *Adv Prev Med*. 2012;2012:1–8.

6. National Heart, Lung, and Blood Institute. *Managing overweight and obesity in adults: aystematic evidence review from the obesity expert panel, 2013*. US Department of Health and Human Services. National Institutes of Health. Bethesda, Maryland; 2013.
7. Executive summary: guidelines (2013) for the management of overweight and obesity in adults. *Obesity*. 2014;(22 Suppl 2):S5–39.
8. Pratt CA, Loria CM, Arteaga SS, Nicastrò HL, Lopez-Class M, de Jesus JM, et al. A systematic review of obesity disparities research. *Am J Prev Med*. 2017;53(1):113–22.
9. Caprio S, Daniels SR, Drewnowski A, Kaufman FR, Palinkas LA, Rosenbloom AL, et al. Influence of race, ethnicity, and culture on childhood obesity: implications for prevention and treatment. *Obesity (Silver Spring, Md)*. 2008;16(12):2566–77.
10. Asghari G, Mirmiran P, Yuzbashian E, Azizi F. A systematic review of diet quality indices in relation to obesity. *Br J Nutr*. 2017;117(8):1055–65.
11. de Rezende LFM, Lopes MR, Rey-López JP, Matsudo VKR, do Carmo Luiz O. Sedentary behavior and health outcomes: an overview of systematic reviews. *PLoS One*. 2014;9(8):e105620.
12. Shaw KA, Gennat HC, O'Rourke P, Del Mar C. Exercise for overweight or obesity. *Cochrane Libr*. 2006;
13. Ledoux T, Hingle M, Baranowski T. Relationship of fruit and vegetable intake with adiposity: a systematic review. *Obes Rev*. 2011;12(5):e143–50.
14. Nago ES, Lachat CK, Dossa RA, Kolsteren PW. Association of out-of-home eating with anthropometric changes: a systematic review of prospective studies. *Crit Rev Food Sci Nutr*. 2014;54(9):1103–16.
15. Mytton OT, Nnoaham K, Eyles H, Scarborough P, Mhurchu CN. Systematic review and meta-analysis of the effect of increased vegetable and fruit consumption on body weight and energy intake. *BMC Public Health*. 2014;14(1):886.
16. Thorp AA, Owen N, Neuhaus M, Dunstan DW. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996–2011. *Am J Prev Med*. 2011;41(2):207–15.
17. Rehm CD, Peñalvo JL, Afshin A, Mozaffarian D. Dietary intake among US adults, 1999–2012. *JAMA*. 2016;315(23):2542–53.
18. Wang DD, Leung CW, Li Y, Ding EL, Chiuve SE, Hu FB, et al. Trends in dietary quality among adults in the United States, 1999 through 2010. *JAMA Intern Med*. 2014;174(10):1587–95.
19. Ford ES, Dietz WH. Trends in energy intake among adults in the United States: findings from NHANES. *Am J Clin Nutr*. 2013;97(4):848–53.
20. Ladabaum U, Mannalithara A, Myer PA, Singh G. Obesity, abdominal obesity, physical activity, and caloric intake in US adults: 1988 to 2010. *Am J Med*. 2014;127(8):717–727.e12.
21. Kelly PM, Davies A, Greig AJ, Lee KK. Obesity prevention in a city state: lessons from New York City during the Bloomberg Administration. *Front Public Health*. 2016;4:60.
22. New York City Department of Parks and Recreation. Shape Up NYC. Date Accessed: 1/29/2018. Available from: https://www.nycservice.org/initiatives/index.php?bitinitiative_id=15.
23. New York City Department of Health and Mental Hygiene. Health Bucks. Available from: <https://www1.nyc.gov/site/doh/health/health-topics/health-bucks.page>. Accessed 22 May 2018.
24. Thorpe LE, Greene C, Freeman A, Snell E, Rodriguez-Lopez JS, Frankel M, et al. Rationale, design and respondent characteristics of the 2013–2014 New York City Health and Nutrition Examination Survey (NYC HANES 2013–2014). *Prev Med Rep*. 2015;2:580–5.
25. Thorpe LE, Gwynn RC, Mandel-Ricci J, Roberts S, Tsoi B, Berman L, et al. Study design and participation rates of the New York City Health and Nutrition Examination Survey, 2004. *Prev Chronic Dis*. 2006;3(3):A94.
26. Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey Data. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. Available from: https://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm. Accessed 2 Feb 2018.
27. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet (London, England)*. 2004;363(9403):157–63.
28. National Health and Nutrition Examination Survey (NHANES): Physician Examination Procedures Manual. Available from: https://www.cdc.gov/nchs/data/nhanes/nhanes_13_14/Phys_Exam_Manual_2013.pdf. Accessed 2 Feb 2018.
29. *Prevention OoD, Promotion H. Healthy People 2020*. Washington, DC: US Department of Health and Human Services. 2013.
30. U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion. Healthy People 2010. Washington, DC Date Accessed: 7/27/2017. Available from: https://www.cdc.gov/nchs/healthy_people/hp2010.htm.
31. Budtz-Jorgensen E, Keiding N, Grandjean P, Weihe P. Confounder selection in environmental epidemiology: assessment of health effects of prenatal mercury exposure. *Ann Epidemiol*. 2007;17(1):27–35.
32. Shields M, Connor Gorber S, Tremblay MS. Estimates of obesity based on self-report versus direct measures. *Health Rep*. 2008;19(2):61–76.
33. Black JL, Macinko J. The changing distribution and determinants of obesity in the neighborhoods of New York City, 2003–2007. *Am J Epidemiol*. 2010;171(7):765–75.
34. Fakhouri TH, Ogden CL, Carroll MD, Kit BK, Flegal KM. *Prevalence of obesity among older adults in the United States, 2007–2010*. US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics. Hyattsville, MD; 2012.
35. Fryar CD, Carroll MD, Ogden CL. *Prevalence of overweight, obesity, and extreme obesity among adults: United States, trends 1960–1962 through 2009–2010*. Hyattsville, MD: National Center for Health Statistics; 2012.
36. Seguin RA, Aggarwal A, Vermeylen F, Drewnowski A. Consumption frequency of foods away from home linked with higher body mass index and lower fruit and vegetable intake among adults: a cross-sectional study. *J Environ Public Health*. 2016;2016:1–12.

37. Park Y, Neckerman KM, Quinn J, Weiss C, Rundle A. Place of birth, duration of residence, neighborhood immigrant composition and body mass index in New York City. *Int J Behav Nutr Phys Act.* 2008;5(1):19.
38. Dee A, Kearns K, O'Neill C, Sharp L, Staines A, O'Dwyer V, et al. The direct and indirect costs of both overweight and obesity: a systematic review. *BMC Res Notes.* 2014;7:242.
39. Doucette ED, Salas J, Scherrer JF. Insurance coverage and diabetes quality indicators among patients in NHANES. *Am J Manag Care.* 2016;22(7):484–90.
40. Winkler MR, Mason S, Laska MN, Christoph MJ, Neumark-Sztainer D. Does non-standard work mean non-standard health? Exploring links between non-standard work schedules, health behavior, and well-being. *SSM Popul Health.* 2018;4:135–43.
41. Wing RR, Phelan S. Long-term weight loss maintenance. *Am J Clin Nutr.* 2005;82(1):222S–5S.