Gender and Race Disparities in Cardiovascular Disease Risk Factors among New York City Adults: New York City Health and Nutrition Examination Survey (NYC HANES) 2013–2014

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Abstract While gender and racial/ethnic disparities in cardiovascular disease (CVD) risk factors have each been well characterized, few studies have comprehensively examined how patterns of major CVD risk factors vary and intersect across gender and major racial/ethnic groups, considered together. Using data from New York City Health and Nutrition Examination Survey 2013–2014—a population-based, cross-sectional survey of NYC residents ages 20 years and older—we measured prevalence of obesity, hypertension, hypercholesterolemia, smoking, and diabetes across gender and race/ethnicity groups for 1527 individuals. We used logistic regression with predicted marginal to estimate age-adjusted prevalence ratio by gender and race/ethnicity groups and assess for potential additive and multiplicative interaction. Overall, women had lower prevalence of CVD risk factors than men, with less hypertension ($p = 0.040$), lower triglycerides ($p < 0.001$), higher HDL ($p < 0.001$), and a greater

likelihood of a heart healthy lifestyle, more likely not to smoke and to follow a healthy diet ($p < 0.05$). When further stratified by race/ethnicity, however, the female advantage was largely restricted to non-Latino white women. Non-Latino black women had significantly higher risk of being overweight or obese, having hypertension, and having diabetes than non-Latino white men or women, or than non-Latino black men ($p < 0.05$). Non-Latino black women also had higher total cholesterol compared to non-Latino black men (184.4 vs 170.5 mg/dL, $p = 0.010$). Despite efforts to improve cardiovascular health and narrow disparities, non-Latino black women continue to have a higher burden of CVD risk factors than other gender and racial/ethnic groups. This study highlights the importance of assessing for intersectionality between gender and race/ethnicity groups when examining CVD risk factors.

Keywords Cardiovascular disease · Race · Gender · Disparities · NYC HANES · Intersectionality

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Introduction

Cardiovascular disease (CVD) is the leading cause of mortality in the USA; annually, more than 700,000 adults die of CVD-related events [1, 2]. The distribution of CVD and its risk factors vary across gender and racial/ethnic groups and are major contributors to health disparities. With respect to gender, men tend to

have a greater preponderance of CVD risk factors at earlier ages, but this pattern shifts in later years, with post-menopausal women having greater increases in blood pressure (BP), cholesterol, and weight than men of similar age [3]. Recent results from the National Health and Nutrition Examination Survey (NHANES) suggest that prevalence of stroke and myocardial infarction have actually increased among women aged 35–54 in the past two decades [4, 5], and ischemic heart disease mortality is declining more slowly among women than men [6]. Regardless of age, once risk factors are present, women are more likely than men to experience CVD [7, 8], due to differential clinical presentation and under-recognition of symptoms [9].

CVD disparities by race/ethnicity are also well characterized. Regardless of socioeconomic status, non-Latino (black) adults have a greater prevalence of CVD risk factors and CVD events than non-Latino white (white) adults [7, 10–12]. Latino adults have higher rates of obesity and diabetes compared with white adults, but lower CVD mortality [13, 14]. CVD patterns also vary substantially across Asian subgroups. Causes of racial and ethnic disparities in CVD are multifactorial, with behavioral, clinical, social, environmental, and biological contributing factors, many of which are not well delineated [15]. Social factors include lower education, lower socioeconomic status, lack of health care access, poorer quality of health care, discrimination, and other inequitable cumulative exposures across the life course [7].

While differences in prevalence of CVD and CVD risk factors have been well characterized by either gender or race/ethnicity [7, 16, 17], few studies have comprehensively examined the cumulative burden of CVD risk factors across gender and race/ethnicity or formally quantified interaction between the two [18, 19]. Understanding collective gender/racial/ethnic disparities across several CVD risk factors can potentially stimulate important new etiologic questions, guide prevention efforts, and stress the relative importance of racial/ethnic disaggregation within gender for CVD research. Using population-based results from New York City Health and Nutrition Examination Survey (NYC HANES) 2013–2014, we examined the distribution of CVD risk factors by gender and race/ethnicity with an intersectionality theoretical perspective.

Methods

Survey Design

NYC HANES 2013–2014 was a population-based, cross-sectional survey modeled on NHANES. Detailed methods of NYC HANES surveys have been previously published [20, 21]. The survey was designed to identify health problems and guide health policy in NYC. A three-stage cluster sampling design was used to select a representative sample of non-institutionalized NYC household residents ages 20 or older. Data collection included a face-to-face interview, computer-assisted interview, brief physical examination, and biologic specimen collection. NYC HANES was approved by the City University of New York, School of Public Health and the New York City Department of Health and Mental Hygiene Institutional Review Boards.

Definitions

History of CVD CVD is defined as self-reported ever receiving a diagnosis of angina, coronary heart disease, myocardial infarction/heart attack, congestive heart failure, or stroke.

CVD Risk Factors Overweight was defined as body mass index (BMI) ≥ 25 kg/m² and < 30 kg/m² and obesity was defined as BMI ≥ 30 kg/m². Three measurements of systolic and diastolic BP (SBP and DBP respectively) were obtained during the physical exam. The averages of the SBP and DBP readings, excluding the first, were calculated. If only one SBP or DBP was measured, it was used as the average. Hypertension was defined as an average SBP ≥ 140 or DBP ≥ 90 mmHg, or self-reported diagnosis of hypertension [22]. Hypercholesterolemia was defined as serum total cholesterol of ≥ 240 mg/dL or self-reported diagnosis of hypercholesterolemia [23]. Diabetes was defined as fasting plasma glucose (FPG) ≥ 126 mg/dL or HbA1C $\geq 6.5\%$ or self-reported diagnosis of diabetes [24]. Diagnosed medical conditions were defined as self-reported diagnosis of the condition. Treatment was defined as self-reported use of prescribed medication among adults diagnosed with the condition.

We analyzed three heart-healthy, protective lifestyle factors: non-smoking, physical activity, and healthy diet. Current non-smoking was defined by a negative response to the question, “Do you currently smoke?”

Participants were defined as physically active if they reported engaging in at least 20 min of vigorous physical activity 3 days a week or at least 30 min of moderate physical activity 5 days a week during the past 30 days, as recommended by Healthy People 2010. Participants were defined as having a healthy diet if they reported consuming at least five portions of fruits or vegetables every day [25].

Data Analyses

Prevalence of overweight, obesity, hypertension, hypercholesterolemia, diabetes, and smoking were calculated by gender, and then stratified by race/ethnicity. For continuous measures of BMI, SBP, DBP, total cholesterol, triglycerides, and LDL- and HDL-cholesterol, mean values and standard deviations were also calculated. We calculated the proportion diagnosed among adults with hypertension, hypercholesterolemia, or diabetes, and the proportion treated with medication among those diagnosed. Relative standard error (RSE) was calculated to assess reliability of results; estimates with $RSE \geq 30$ were considered unreliable.

Logistic regression models using the SUDAAN PREDMARG statement was used to obtain age-adjusted prevalence ratio of the following risk factors separately: overweight/obesity, hypertension, hypercholesterolemia, $LDL \geq 100$ mg/dL, diabetes, and smoking by gender-and-race/ethnicity groups [26]. Multiplicative and additive interaction between race/ethnicity and gender were also tested in each model. White men were set as the common referent group and relative excess risk due to interaction (RERI) was calculated to measure additive interaction or the departure from additivity of effects on a relative-risk scale [27, 28]. $RERI > 0$ indicates a positive additive interaction, $RERI < 0$ indicates a negative additive interaction, and $RERI = 0$ indicates no additive interaction. We also used the PRED_EFF statement with RLOGIST to estimate and test the difference in prevalence between white and black adults for each CVD risk factor, separately for men and women. Prevalence difference between white and black men was contrasted to the prevalence difference between white and black women using the same method. Sensitivity analyses adjusting for education and neighborhood poverty for each binomial regression model were performed. All estimates were age standardized to the 2000 US population. *T* tests were used to assess the differences in CVD risk factors and management between men and women; a two-tailed *p* value

< 0.05 was used to determine statistical significance. Data were weighted to account for complex survey design, non-response, and post-stratification. Weights were further adjusted to account for item non-response. SAS 9.4 (SAS Institute Inc., Cary, NC) and SUDAAN 11.0.1 (Research Triangle Institute, Research Triangle Park, NC) were used for all analyses.

Results

Study Population Characteristics

In 2013–2014, a plurality of NYC adults was white (35.0%), followed by Latino (27.1%), black (21.3%), and non-Latino Asian (Asian) (14.0%). A greater proportion of men than women had more than high school education (61.5% vs 54.1%, $p = 0.003$) and had annual household income $\geq \$20,000$ (76.5% vs 66.9%, $p < 0.001$). A greater proportion of white adults had more than high school education (79.7%), compared to Asian (62.0%), black (45.5%), and Latino adults (34.7%). White adults also were most likely to have household income $\geq \$20,000$ (84.3%), followed by Asian (71.0%), black (67.8%), and Latino adults (56.1%).

CVD Risk by Gender

Table 1 shows mean values of continuous CVD risk factors among NYC adults in 2013–2014. Compared to men, women had lower mean SBP (119.6 vs 127.4 mmHg, $p < 0.001$), DBP (76.3 vs 79.2 mmHg, $p < 0.001$), and triglycerides (90.0 vs 113.2 mg/dL, $p < 0.001$), and had higher mean HDL-cholesterol (62.0 vs 50.5 mg/dL, $p < 0.001$). There were no significant differences between men and women in average BMI and LDL-cholesterol.

Prevalence of categorical CVD risk factors among NYC adults is also presented in Table 1. Men had a greater prevalence of hypertension than women (41.1% vs 35.9%, $p = 0.040$), however, women diagnosed with hypertension were more likely to use medication (61.7% vs 48.6%, $p = 0.014$). In terms of heart healthy behaviors, more women than men reported not smoking (83.7% vs 79.1%, $p = 0.033$) and eating at least five portions of fruits and vegetables daily (6.6% vs 3.9%, $p = 0.033$), while a greater proportion of men than women reported physical activity (35.2% vs 25.7%, $p = 0.001$).

Table 1 Cardiovascular disease risk factors among NYC adults aged 20 and older by gender and major race/ethnic groups. NYC HANES 2013–2014

	Men (<i>N</i> = 642)		Women (<i>N</i> = 885)		
	<i>N</i>	Mean (SD) or % (95%CI)	<i>N</i>	Mean (SD) or % (95%CI)	<i>p</i> value
Total					
CVD risk factors					
BMI*	622	27.8 (6.4)	847	28.1 (8.4)	0.510
% overweight*	622	37.3 (33.3–41.5)	847	31.5 (27.9–35.3)	0.072
% obese*	622	30.2 (26.1–34.7)	847	31.1 (27.6–34.9)	0.765
Systolic blood pressure	622	127.4 (22.1)	859	119.6 (20.7)	< 0.001
Diastolic blood pressure	622	79.2 (12.7)	859	76.3 (12.8)	< 0.001
% hypertension	630	41.1 (37.3–45.1)	867	35.9 (32.2–39.8)	0.040
% diagnosed hypertension	249	73.0 (66.5–78.7)	294	76.6 (68.7–82.9)	0.442
% treated with medication^	182	48.6 (42.3–54.9)	235	61.7 (53.5–69.3)	0.014
Total cholesterol (mg/dL)	429	185.4 (47.3)	571	189.9 (45.6)	0.125
Triglycerides (mg/dL)	429	113.2 (95.7)	571	90.0 (73.5)	< 0.001
LDL cholesterol (mg/dL)	424	112.5 (40.1)	566	109.6 (39.4)	0.265
HDL cholesterol (mg/dL)	429	50.5 (15.8)	571	62.0 (20.7)	< 0.001
% hypercholesterolemia (high CHOL)	480	41.9 (37.5–46.5)	660	42.7 (38.5–47.0)	0.801
% diagnosed high CHOL	197	89.6 (83.1–93.8)	269	89.6 (83.4–93.7)	0.997
% treated with medication	179	38.3 (31.4–45.8)	243	30.3 (25.4–35.7)	0.043
% diabetes	523	15.8 (12.9–19.2)	723	16.2 (13.4–19.4)	0.858
% diagnosed diabetes	81	83.6 (66.8–92.8)	110	78.8 (61.3–89.7)	0.610
% treated with medication	68	92.8 (85.0–96.7)	90	89.1 (71.2–96.4)	0.567
CVD history					
Any history of CVD	642	7.3 (5.4–9.7)	885	6.5 (4.6–9.1)	0.569
Heart healthy lifestyle					
% currently not smoking	641	79.1 (75.1–82.6)	883	83.7 (80.5–86.4)	0.033
% physically active	605	35.2 (30.9–39.8)	823	25.7 (22.7–29.0)	0.001
% fruits and vegetable consumption	642	3.9 (2.4–6.2)	885	6.6 (5.0–8.8)	0.033
All 3 heart healthy components	639	1.8 (1.0–3.5)	883	2.4 (1.4–4.0)	0.542
Non-Latino white					
CVD risk factors					
BMI*	231	28.2 (6.6)	260	26.5 (7.4)	0.007
% overweight*	231	37.1 (30.2–44.5)	260	24.8 (19.6–30.9)	0.012
% obese*	231	32.0 (25.0–39.9)	260	23.4 (18.5–29.1)	0.071
Systolic blood pressure	231	125.0 (19.2)	265	115.8 (15.5)	< 0.001
Diastolic blood pressure	231	77.9 (9.9)	265	74.7 (9.8)	< 0.001
% hypertension	236	38.7 (32.6–45.2)	267	24.2 (18.8–30.5)	0.001
% diagnosed hypertension	89	73.1 (61.4–82.3)	65	68.2 (51.7–81.2)	0.612
% treated with medication	65	39.4 (30.9–48.6)	48	63.5 (37.7–83.3)	0.075
Total cholesterol (mg/dL)	174	193.2 (39.6)	205	193.4 (35.7)	0.953
Triglycerides (mg/dL)	174	118.7 (108.5)	205	84.1 (71.7)	< 0.001
LDL cholesterol (mg/dL)	171	119.9 (30.7)	203	107.1 (31.1)	< 0.001

Table 1 (continued)

	Men (<i>N</i> = 642)		Women (<i>N</i> = 885)		<i>p</i> value
	<i>N</i>	Mean (SD) or % (95%CI)	<i>N</i>	Mean (SD) or % (95%CI)	
HDL cholesterol (mg/dL)	174	50.3 (15.2)	205	69.2 (23.4)	<0.001
% hypercholesterolemia (high CHOL)	191	42.1 (35.9–48.6)	227	46.0 (39.8–52.4)	0.352
% diagnosed high CHOL	80	89.3 (75.9–95.7)	102	88.7 (79.0–94.3)	0.926
% treated with medication	75	29.3 (22.6–37.0)	90	33.2 (23.8–44.1)	0.540
% diabetes	199	8.4 (5.3–13.2)	236	7.0 (4.4–11.1)	0.570
% diagnosed diabetes	18	36.7 (22.6–53.7)	16	94.3 (84.8–98.0)	<0.001
% treated with medication	12	77.8 (38.0–95.2)	14	95.8 (75.3–99.4)	0.285
CVD history					
Any history of CVD	241	8.0 (5.7–11.0)	272	3.1 (1.7–5.6)	0.003
Heart healthy lifestyle					
% currently not smoking	240	80.9 (74.1–86.3)	271	82.3 (77.1–86.6)	0.710
% physically active	233	38.6 (32.2–45.4)	255	28.0 (22.7–34.0)	0.011
% fruits and vegetable consumption	241	8.0 (4.7–13.3)	272	13.6 (9.8–18.6)	0.057
All 3 heart healthy components	240	4.2 (2.1–8.0) [†]	271	4.5 (2.4–8.2) [†]	0.880
Non-Latino black					
CVD risk factors					
BMI*	120	28.0 (7.6)	203	30.2 (8.7)	0.017
% overweight*	120	28.9 (19.7–40.2)	203	38.5 (30.8–46.9)	0.195
% obese*	120	33.0 (24.1–43.4)	203	39.6 (31.6–48.1)	0.339
Systolic blood pressure	121	131.1 (32.4)	210	125.8 (22.3)	0.137
Diastolic blood pressure	121	80.4 (19.2)	210	78.7 (15.2)	0.475
% hypertension	122	42.6 (33.1–52.6)	211	52.1 (45.5–58.6)	0.120
% diagnosed hypertension	53	83.3 (66.5–92.6)	106	71.2 (57.5–81.9)	0.213
% treated with medication	44	58.6 (43.7–72.0)	85	66.0 (55.6–75.1)	0.451
Total cholesterol (mg/dL)	78	170.5 (41)	114	184.4 (42.8)	0.010
Triglycerides (mg/dL)	78	87.3 (64.7)	114	73.1 (55.1)	0.108
LDL cholesterol (mg/dL)	77	100.7 (40.7)	114	110.7 (36.7)	0.065
HDL cholesterol (mg/dL)	78	52.6 (13)	114	59.1 (21.2)	0.005
% hypercholesterolemia (high CHOL)	90	37.0 (28.5–46.5)	139	45.5 (38.2–53.0)	0.104
% diagnosed high CHOL	34	87.3 (67.1–95.9)	62	84.2 (66.5–93.4)	0.752
% treated with medication	31	38.3 (26.2–52.0)	53	30.4 (22.2–39.9)	0.324
% diabetes	101	19.3 (13.9–26.0)	161	22.5 (16.3–30.4)	0.473
% diagnosed diabetes	20	100.0	34	86.5 (76.0–92.8)	0.001
% Treated with medication	20	98.8 (91.6–99.8)	26	98.5 (91.2–99.8)	0.871
CVD history					
Any history of CVD	125	7.8 (4.2–14.2) [†]	215	9.6 (6.1–14.9)	0.484
Heart healthy lifestyle					
% currently not smoking	125	76.0 (64.8–84.5)	215	79.1 (70.9–85.5)	0.530
% physically active	117	34.3 (25.6–44.2)	193	26.5 (20.4–33.6)	0.136
% fruits and vegetable consumption	125	0.8 (0.1–5.3) [†]	215	2.3 (0.8–6.4) [†]	0.294
All 3 heart healthy components	125	0.0 [†]	214	0.7 (0.1–4.9) [†]	0.305

Table 1 (continued)

	Men (<i>N</i> = 642)		Women (<i>N</i> = 885)		
	<i>N</i>	Mean (SD) or % (95%CI)	<i>N</i>	Mean (SD) or % (95%CI)	<i>p</i> value
Latino					
CVD risk factors					
BMI*	154	28.5 (5.6)	228	29.2 (7.4)	0.270
% overweight*	154	39.2 (30.9–48.3)	228	34.2 (28.5–40.3)	0.346
% obese*	154	35.5 (27.4–44.4)	228	37.9 (31.0–45.3)	0.683
Systolic blood pressure	155	128.0 (14.7)	228	119.2 (18.3)	< 0.001
Diastolic blood pressure	155	79.8 (11.2)	228	76.1 (12)	< 0.001
% hypertension	155	40.8 (32.8–49.3)	231	35.9 (29.7–42.7)	0.308
% diagnosed hypertension	59	68.8 (52.0–81.7)	80	85.8 (75.8–92.1)	0.068
% treated with medication	41	40.3 (29.6–52.0)	68	47.0 (39.3–54.9)	0.326
Total cholesterol (mg/dL)	103	181.0 (41.4)	143	188.5 (52.5)	0.206
Triglycerides (mg/dL)	103	122.9 (70.8)	143	99.7 (65.3)	0.015
LDL cholesterol (mg/dL)	102	108.6 (35.3)	142	109.6 (42.5)	0.829
HDL cholesterol (mg/dL)	103	47.6 (11)	143	58.5 (17.6)	< 0.001
% hypercholesterolemia (high CHOL)	115	42.2 (31.3–53.9)	174	38.8 (30.3–48.1)	0.604
% diagnosed high CHOL	48	93.1 (84.0–97.2)	66	97.6 (91.4–99.3)	0.205
% treated with medication	43	32.1 (25.1–40.0)	64	30.0 (21.8–39.7)	0.718
% diabetes	129	19.2 (13.6–26.2)	196	19.6 (14.6–25.9)	0.914
% diagnosed diabetes	25	77.1 (57.3–89.4)	39	92.9 (84.8–96.8)	0.083
% treated with medication	20	91.5 (70.2–98.0)	34	70.9 (39.6–90.1)	0.173
CVD history					
Any history of CVD	155	8.0 (4.4–14.2)	235	7.8 (4.4–13.5)	0.951
Heart healthy lifestyle					
% currently not smoking	155	80.1 (72.0–86.3)	234	84.8 (79.6–88.9)	0.261
% physically active	140	34.5 (27.2–42.7)	220	25.5 (19.6–32.6)	0.102
% fruits and vegetable consumption	155	1.1 (0.3–4.5) [†]	235	1.5 (0.5–4.3) [†]	0.756
All 3 heart healthy components	154	0.5 (0.1–3.6) [†]	235	0.9 (0.2–4.1) [†]	0.607
Non-Latino Asian					
CVD risk factors					
BMI*	81	25.7 (5.5)	114	25.8 (4.7)	0.831
% overweight*	81	47.1 (34.4–60.1)	114	32.7 (22.8–44.5)	0.117
% obese*	81	13.9 (6.2–28.4) [†]	114	18.6 (12.0–27.7)	0.414
Systolic blood pressure	79	130.5 (20.2)	114	118.7 (22.3)	< 0.001
Diastolic blood pressure	79	80.0 (9)	114	75.3 (14.2)	0.002
% hypertension	81	47.5 (35.9–59.4)	116	35.8 (26.9–45.9)	0.119
% diagnosed hypertension	32	73.1 (57.0–84.8)	30	90.7 (76.3–96.7)	0.029
% treated with medication	23	61.0 (47.1–73.3)	26	72.8 (51.4–87.2)	0.331
Total cholesterol (mg/dL)	54	191.5 (53.3)	79	191.1 (43.5)	0.964
Triglycerides (mg/dL)	54	132.7 (125.7)	79	127.1 (139.3)	0.830
LDL cholesterol (mg/dL)	54	114.3 (36.5)	77	109.4 (38.1)	0.386
HDL cholesterol (mg/dL)	54	50.6 (12.5)	79	56.6 (21.5)	0.027
% hypercholesterolemia (high CHOL)	59	41.7 (27.4–57.6)	87	37.8 (28.2–48.6)	0.665

Table 1 (continued)

	Men (<i>N</i> = 642)		Women (<i>N</i> = 885)		<i>p</i> value
	<i>N</i>	Mean (SD) or % (95%CI)	<i>N</i>	Mean (SD) or % (95%CI)	
% diagnosed high CHOL	25	86.4 (64.9–95.6)	28	85.9 (61.7–95.8)	0.951
% treated with medication	21	61.0 (46.2–74.0)	25	18.3 (9.0–33.7) [†]	< 0.001
% diabetes	68	25.3 (15.8–37.9)	94	22.7 (15.5–32.0)	0.722
% diagnosed diabetes	15	97.6 (84.6–99.7)	15	49.5 (34.4–64.6)	< 0.001
% treated with medication	14	90.8 (71.7–97.5)	11	89.3 (65.1–97.4)	0.866
CVD history					
Any history of CVD	84	0.0	120	4.8 (1.6–13.7) [†]	0.073
Heart healthy lifestyle					
% currently not smoking	84	79.4 (70.0–86.4)	120	89.6 (82.7–94.0)	0.054
% physically active	81	28.0 (17.7–41.3)	116	19.8 (12.6–29.6)	0.327
% fruits and vegetable consumption	84	1.8 (0.4–7.7) [†]	120	7.0 (2.8–16.5) [†]	0.161
All 3 heart healthy components	83	0.0 [†]	120	2.4 (0.5–11.5) [†]	0.227

All estimates are age standardized to the 2000 US population

*Pregnant women were excluded

[†] Relative standard error (RSE) $\geq 30\%$, estimate is potentially unreliable and should be interpreted with caution

CVD Risk by Sex and Race/Ethnicity

When sex-specific estimates were further stratified by race/ethnicity, important differences were noted. While BMI was similar between men and women overall, white women had lower average BMI than white men (26.5 vs 28.2, $p = 0.007$) and were less likely to be overweight (24.8% vs 37.1%, $p = 0.012$). In contrast, black women had higher average BMI than black men (30.2 vs 28.0 kg/m², $p = 0.017$) and, although not statistically significant, were more likely to be overweight (38.5% vs 28.9%, $p = 0.195$) and obese (39.6% vs 33.0%, $p = 0.339$) (Table 1).

Among white, Asian, and Latino New Yorkers, average SBP and DBP were lower for women than men ($p < 0.05$). In contrast, average SBP and DBP were similar for black women and men. In addition, white women had lower prevalence of hypertension than white men (24.2% vs 38.7%, $p = 0.001$). In contrast, the data suggest that the prevalence of hypertension among black women was greater than among black men, though the difference was not statistically significant (52.1% vs 42.6%, $p = 0.120$). Latino and Asian men and women had similar overall levels of hypertension, but Latino and Asian women were more likely than men to be diagnosed (Latino—85.8% vs 68.8%, $p = 0.068$; Asian—90.7% vs 73.1%, $p = 0.029$) (Table 1).

Overall, mean LDL-cholesterol and total cholesterol levels were similar between men and women, but white women had a lower mean LDL-cholesterol than white men (107.1 vs 119.9 mg/dL, $p < 0.001$). In contrast, black women had higher mean LDL-cholesterol than black men (110.7 vs 100.7 mg/dL, $p = 0.065$). Total cholesterol differed by gender only among black adults, where women had higher total cholesterol than men (184.4 vs 170.5 mg/dL, $p = 0.010$). Women of all racial/ethnic groups had higher mean HDL-cholesterol than men ($p < 0.05$). Mean triglycerides was higher among men than women across all racial/ethnic groups, although not always significantly so. Prevalence of hypercholesterolemia was comparable between men and women across racial/ethnic groups, except for black adults. Although not significant, black women had higher prevalence of hypercholesterolemia than black men (45.5% vs 37.0%, $p = 0.104$) (Table 1).

Diabetes prevalence was comparable between men and women in all racial/ethnic groups. Among white adults with diabetes, however, the percentage diagnosed was greater among women than that among men (94.3% vs 36.7%, $p < 0.001$). In contrast, among black and Asian New Yorkers with diabetes, men were more likely than women to be diagnosed (black—100% vs 86.5%, $p = 0.001$; Asian—97.6% vs 49.5%, $p < 0.001$), although gender-specific sample sizes were small (Table 1).

In general, sex-specific directionality of heart healthy behaviors was comparable across all races/ethnicities. Men were more likely than women to be physically active among all race/ethnicity groups. However, only significantly so among white adults. Women were more likely than men to follow recommendations for fruits and vegetables (6.6% vs 3.9%, $p = 0.033$); this remained statistically significant only among white adults (Table 1).

When examining history of CVD, white women had a lower prevalence than white men (3.1% vs 8.0%, $p = 0.003$), whereas other groups had no gender-specific difference (Table 1).

Interactions

Table 2 explores the age-adjusted multiplicative interaction by gender and race/ethnicity for CVD risk factors, using white men as the common referent group. For two of the six CVD risk factors examined—overweight/obesity and hypertension—the direction of association between gender and CVD risk factors significantly differed across racial/ethnic groups, with white women having a lower prevalence ratio of a CVD risk factor and black women having a higher prevalence ratio. For example, relative to white men, black women were 20% more likely to be overweight or obese (95%CI 1.0–1.3; $p = 0.013$) and 40% more likely to have hypertension (95%CI 1.2, 1.8; $p = 0.001$); white women, however, had significantly lower prevalence of either condition than white men ($p < 0.05$). An almost-similar pattern was noted for diabetes: whereas white men and women did not significantly differ in prevalence of diabetes, black women had 3.2 times greater prevalence of diabetes than white men (95%CI 1.8, 5.9). Latino men and women were comparable in having a higher prevalence of diabetes than white men (2.7, 95%CI 1.5–5.0, and 2.6, 95%CI 1.5–4.5, respectively). Asian men had higher risk of diabetes than white men (3.9, 95%CI 2.1–7.3), as did Asian women (2.7, 95%CI 1.4–5.3); however, the sample size for Asian men was relatively small, and results should be interpreted with caution. While direction and magnitude of associations differed across gender and race/ethnicity in most of the regression models, multiplicative interaction was significant only for overweight/obesity and hypertension ($p < 0.050$). Further adjustment for education and neighborhood poverty did not change the association observed in this analysis.

Our calculated measure of interaction on the additive scale among white and black populations, RERI, was elevated (> 0): 0.6 for overweight/obesity and 0.5 for hypertension, additionally, the prevalence difference between black and white adults was larger among women than men in overweight/obesity ($p < 0.001$) and hypertension ($p = 0.002$) (Table 3). These findings suggest the presence of significant positive additive interaction. In other words, the combined effect of being black and being a woman was larger than the individual effect of these demographics on overweight/obesity and hypertension. These findings suggest that gender differences in CVD risk factor burden varied by racial/ethnic group. For example, among white adults, risk factor profiles tended to be either worse for men or similar between genders, whereas among black adults, risk factor profiles were consistently worse for women than men.

Discussion

This study characterized the variability in CVD risk across gender and race/ethnicity in NYC using objective biomeasure data. Our findings underscore an important epidemiologic distinction—that gender-based differences in CVD risk cannot be generalized across all racial/ethnic groups. Among groups examined, black women had the highest prevalence of CVD risk factors and white women had the lowest. Consistent with a large but disparate body of evidence on social and environmental differences in CVD risk by race and gender, and on hormonal differences by gender [7], our findings emphasize the importance of examining gender and race simultaneously.

The scope of this study is novel, as it quantifies the moderating effects of race/ethnicity on gender for a range of CVD risk factors. Previous studies examined differences in CVD risks, history, and mortality either by gender or by race/ethnicity, and showed that CVD and CVD risk factors, including hypertension, diabetes, hypercholesterolemia, obesity, and sedentary lifestyle, were more prevalent among black than white adults [10–12, 29]. Previous studies have also identified that prevalence of CVD risk factors among women usually does not exceed that among men until older ages, albeit with excess CVD events and mortality among women once CVD risk factors are present [30]. A recent nationwide prospective study of adults ages 45 and older found that black men had higher risk of fatal coronary

Table 2 Age-adjusted prevalence ratio of cardiovascular disease risk factors among NYC men and women from major race/ethnic groups. NYC HANES 2013–2014

	CVD risk factors					
	Overweight or obese [‡]	Hypertension	Hypercholesterolemia	High LDL cholesterol (≥ 100 mg/dL)	Diabetes	Smoking
	aPR (95%CI)	aPR (95%CI)	aPR (95%CI)	aPR (95%CI)	aPR (95%CI)	aPR (95%CI)
Men						
NL White	Ref	Ref	Ref	Ref	Ref	Ref
NL Black	0.9 (0.7–1.1)	1.2 (0.9–1.6)	0.9 (0.7–1.2)	0.8 (0.6–1.1)	2.7 (1.5–4.9)**	1.3 (0.8–2.2)
Latino	1.1 (1.0–1.3)	1.1 (0.9–1.5)	1.1 (0.8–1.5)	0.8 (0.7–1.0)	2.7 (1.5–5.0)**	1.0 (0.6–1.7)
Asian	0.9 (0.7–1.1)	1.3 (1.0–1.7)	1.2 (0.8–1.8)	1.1 (0.9–1.3)	3.9 (2.1–7.3)***	1.3 (0.8–2.1)
Women						
NL White	0.7 (0.6–0.8)***	0.7 (0.5–0.9)**	1.1 (0.9–1.4)	0.9 (0.7–1.0)	0.9 (0.4–1.7)	0.9 (0.6–1.4)
NL Black	1.2 (1.0–1.3)*	1.4 (1.2–1.8)**	1.2 (0.9–1.5)	0.8 (0.7–1.0)	3.2 (1.8–5.9)***	1.1 (0.7–1.8)
Latino	1.1 (0.9–1.2)	1.0 (0.8–1.2)	1.0 (0.7–1.3)	1.0 (0.8–1.1)	2.6 (1.5–4.5)**	0.8 (0.5–1.3)
Asian	0.7 (0.6–0.9)**	0.9 (0.7–1.3)	0.9 (0.7–1.3)	0.9 (0.8–1.1)	2.7 (1.4–5.3)**	0.6 (0.3–1.0)*

[‡] Pregnant women were excluded* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

heart disease (CHD) than white men, while black women had higher risk of both fatal and non-fatal CHD than white women. Excess CHD risk among black adults was mainly attributed to higher prevalence of CVD risk factors [10]. These results are similar to ours, but they did not explicitly contrast all four groups against each other and thus did not shed light on the differences across gender and race combinations. Similarly, recently published national studies identified worsening trends in incident CHD and stroke among middle-aged women, but did not stratify results by race/ethnicity [4, 5]. One recent study, however, used NYC vital statistics from 1980 to 2008 to examine gender and race/ethnicity variability in ischemic heart disease mortality. The

authors observed overall declines in mortality rates over time among younger but not older adults, and found that young black women (ages 30–44) had higher mortality rates and significantly slower declines in mortality rates than young women in other racial/ethnic groups [31]. With respect to elevated BP, studies found elevated nighttime BP among black adults, increasing their risk for CVD; however, no stratification by gender was included [32, 33]. In terms of BMI, a recent trend analysis identified a narrowing of the gap in obesity between black and white men, while the gap between black and white women has remained consistent [34]. National studies of diabetes prevalence have highlighted increases in all race/ethnicity and sex groups [35]. None

Table 3 Relative Excess Risk due to Interaction (RERI) of race and gender, and race difference in cardiovascular disease risk among NYC non-Latino white and non-Latino black adults. NYC HANES 2013–2014

CVD risk factors	RERI	Difference in prevalence between black and white adults		
		Men	Women	<i>p</i> value
Overweight or obese*	0.6	−0.05	0.31	<0.001
Hypertension prevalence	0.5	0.07	0.28	0.002
High cholesterol (≥ 240 mg/dL)	0.2	−0.02	0.01	0.562
LDL cholesterol (≥ 100 mg/dL)	0.1	−0.15	−0.02	0.193
Diabetes prevalence	0.6	0.13	0.18	0.357
Smoking prevalence	−0.1	0.05	0.04	0.887

*Pregnant women were excluded

of these studies, however, examined racial/ethnic and gender variability together.

One perspective into how gender and race together engender CVD risk is the sociological framework of “intersectionality,” which stresses the importance of how gender, race, and class experiences interact in a multi-dimensional basis that produce health inequities [36]. Being a woman and being black, each presents unique psychosocial experiences that influence attitudes toward health, access to health, and healthy lifestyle choices, which altogether affect CVD risk. An intersectionality framework counters the prevailing view that women are a homogenous category sharing the same life experiences, and instead emphasizes that being a black woman is more than just the sum of being black and being female. Using data from NYC, where multiple racial/ethnic groups live in a relatively small geographic area, we explored multiplicative and additive interaction between gender and race/ethnicity, and found that the combined effects of gender and race/ethnicity on overweight/obesity and hypertension were greater than the sum of individual gender and race/ethnicity effects. Black women in NYC have a disadvantaged CVD risk profile driven by differential effects of gender, race, and the combined effect of gender and race.

Exact factors driving different race/gender patterns likely include different environmental risks across the life-course. Cumulative exposure to racism, lower socioeconomic status, neighborhood poverty, and lower quality of medical care are increasingly recognized as important social determinants of overall health, CVD, and CVD risk factors [37–41]. Heart disease mortality is higher among black adults compared to white adults across income groups [42]. Studies on the influence of neighborhoods have identified that black adults are more likely to experience the effects of segregation, such as limited access to good education, jobs, and high-quality health care [42]. Low-income neighborhoods also have limited healthy food and beverage choices and fewer safe places for physical activity, which could contribute to obesity and increased risk of CVD [43]. Furthermore, studies among low-income women show that black women have disproportionate challenges following diet and activity guidelines due to heavy caretaking responsibilities, inflexible work schedules, and competing health issues [44].

Our study has several limitations. Because of the small sample, we were unable to stratify by additional factors, like age, and were unable to examine how

CVD risk factor prevalence varies between black and white women by pre/post-menopausal stage [7]. This analysis was based on cross-sectional data, limiting our ability to investigate the causes for the observed patterns. We relied on laboratory and physical examination at a single time point to determine undiagnosed hypertension, diabetes, and hypercholesterolemia, whereas such determinations in clinical settings generally require repeated testing. Nonetheless, our study has distinctive strengths. Results were based on population-based examination, with biomeasure and questionnaire benchmarked against NHANES. Furthermore, our study was conducted in a single ethnically diverse urban municipality, allowing us to examine racial/ethnic differences in CVD risk without the conflating influences of mixing urban and rural or of large geographic regions.

Despite the overall improving trends in CVD incidence in the USA, our study underscores that black women in NYC have substantially worse CVD risk profiles than other gender/racial groups and thus are at disproportionate risk for CVD. These differences in CVD risk warrant closer attention, including individual and population-level interventions that address both prevention and control of CVD risk among black women. Further studies are needed to confirm gender-and-racial/ethnic-specific divergences in CVD risk profile in other locales, and to measure other factors, such as access to and quality of health care, discrimination, and inequality. Such studies may indicate how social factors contribute to gender/racial differences in CVD risk and may identify evidence-based interventions to reduce racial/ethnic disparities in CVD risk.

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