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Associations of overweight/obesity and socioeconomic status with hypertension prevalence across racial and ethnic groups

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Racial/ethnic disparities in the prevalence of diagnosed hypertension are persistent but may be partially explained by racial/ethnic differences in weight category and neighborhood socioeconomic status. The authors compared hypertension prevalence rates among 4 060 585 adults with overweight or obesity across 10 healthcare systems by weight category and neighborhood education level in geographically and racially diverse individuals. Data were obtained from electronic health records. Hypertension was defined as at least two outpatient visits or one inpatient hospitalization with a coded diagnosis. Logistic regression, adjusted for age, sex, and site, with two-way interactions between race/ethnicity and weight category or neighborhood education, was used to examine the association between hypertension and race/ethnicity, with whites as the reference. Results documented that odds ratios for hypertension prevalence were greater for blacks, American Indians/Alaskan Natives, Asians, and Native Hawaiians/other Pacific Islanders compared with whites and lower for Hispanics in similar weight categories and neighborhood education levels. Although two-way interactions were statistically significant, the magnitude of the odds of hypertension compared with whites did not substantially vary across weight or neighborhood education. Hypertension odds were almost double relative to whites for blacks and Native Hawaiians/other Pacific Islanders across most weight categories and all neighborhood education levels. Odds of hypertension were about 50% greater for Asians relative to whites across weight categories. Results suggest that other factors might be associated with racial/ethnic disparities in hypertension. More research is needed to understand the many factors that may contribute to variation in diagnosed hypertension across racial/ethnic groups with overweight or obesity.

1 | INTRODUCTION

Hypertension is one of the most important modifiable risk factors for cardiovascular disease and stroke.[1] Racial and ethnic disparities in hypertension are well documented with national prevalence rates ranging from about 29.0% for Asians to about 45.0% and 46.3% for black men and women, respectively.[2]

Other than race and ethnicity, risk factors for developing hypertension include age, family history, overweight/obesity, individual and neighborhood socioeconomic status (SES), and lifestyle factors such as

physical activity, dietary patterns, and tobacco use.[2] Overweight and obesity have a steep racial gradient, with the highest prevalence rate among black and Hispanic adults and the lowest prevalence among Asians.[3] Additionally, it is well established that being overweight/obese is associated with lower SES at both individual and neighborhood levels.[4-6] Given that some racial/ethnic minorities, particularly blacks and Hispanics, disproportionately live in low SES neighborhoods compared with non-Hispanic whites,[7,8] it is plausible that the racial/ethnic differences in hypertension prevalence may be partially explained by combinations of overweight/obesity and low SES neighborhoods.

Little is known about how weight and SES level may interact to influence hypertension prevalence for racial/ethnic minorities compared with whites. A few studies have documented that hypertension prevalence may differ within weight class by race/ethnicity[9–11] and some have assessed hypertension prevalence by SES and race,[12–14] but we do not know whether SES may be associated with hypertension differently within weight categories for different race/ethnicities. For instance, low SES may be associated with greater prevalence of hypertension for overweight racial/ethnic minorities compared with overweight whites with the same SES. Further, prior studies assessed race-SES or race-weight interactions for only one or two racial/ethnic groups and rarely included urban and rural populations across large geographic regions. Identifying potential heterogeneity in associations may lead to a better understanding of racial/ethnic disparities in hypertension prevalence among overweight/obese adults. Without understanding potential interactions of SES, weight category, and race/ethnicity with hypertension prevalence, the most vulnerable groups that have the greatest need for interventions may be missed.

The aim of this study was to examine the prevalence of diagnosed hypertension in a large racially/ethnically and regionally diverse cohort of overweight and obese adults and to determine whether prevalence of hypertension varied by weight and neighborhood education categories. Our large sample size (>4 million), assembled across most US geographical regions, enabled us to examine associations across six racial/ethnic categories (black, American Indian/Alaskan Native, Asian, Hispanic, Native Hawaiian/other Pacific Islander, and non-Hispanic white). We hypothesized that individuals in the same weight and neighborhood education categories would have similar hypertension prevalence regardless of race/ethnicity. Results from this study may provide unique information that could lead to better targeting of interventions, not only by race/ethnicity but possibly by weight category or SES, to reduce hypertension.

2 | METHODS

Data for this study come from Patient Outcomes Research to Advance Learning (PORTAL), one of the Patient-Centered Outcomes Research networks (PCORnet). PORTAL is a combination of healthcare delivery systems that have a total of approximately 11 million members.[15] The network includes all Kaiser Permanente regions (Hawaii, Northwest [Northern Oregon and Southwest Washington], Northern California, Southern California, Colorado, Mid-Atlantic States [Maryland, Virginia, and District of Columbia], Georgia [through 2015], and Washington), HealthPartners (Minnesota and Wisconsin), and Denver Health (Denver Colorado).

The PORTAL overweight/obesity cohort was previously described elsewhere.[16] For this study, we included adults older than 18 years and, for all race/ethnicities except Asians, those with a body mass index (BMI; kg/m^2) ≥25.0 recorded in their electronic health record in 2012 or 2013. For Asians, we included those with BMI ≥23.0, using the World Health Organization overweight/obesity cut point recommendations for Asians.[17] For all sites except Denver Health, inclusion criteria consisted of health plan members with at least 12 months of continuous membership between January 1, 2012, and December 31, 2013, who were aged at least 18 years on December 31, 2013, and who were not pregnant during 2012–2013. For Denver Health, the initial eligibility criteria included all adults who had a primary care encounter during 2012–2013 because this organization, as a safety-net organization, does not have an associated health plan for enrolling members.

We used the Health Care Systems Research Network Virtual Data Warehouse for data extraction. The Virtual Data Warehouse is a standardized and federated database in which all data reside at each health system behind each site's security system, or firewall.[18] The Kaiser Permanente Southern California's institutional review board approved the research. The institutional review boards at the other sites reviewed the protocol and subsequently ceded review.

2.1 | Hypertension

Hypertension was defined as at least two outpatient visits with a coded diagnosis of hypertension or one inpatient hospitalization with a coded diagnosis of hypertension, defined as *International Classification of Diseases, Ninth Revision*, codes of 401.xxx-405.xxx between 2009 and 2013. We did not use elevated systolic or diastolic blood pressure for defining hypertension because of possible inaccuracies of one measure. To confidently identify undiagnosed hypertension from blood pressure assessments, multiple measurements would have been required, but cohort requirements were simply one outpatient visit in 2012 or 2013. We had no reason to suspect undiagnosed hypertension would differ by race/ethnicity or neighborhood education level.

2.2 | Weight and Height

Weight is routinely measured during outpatient clinic visits, while height is generally considered static for adults and less frequently assessed, although it is recorded in the electronic health record. BMI was calculated as weight (kg) divided by height squared (m^2). If more than one weight, height, or BMI value was available in 2012/2013, the most recent value was used. We excluded 6954 individuals (0.1%) because of biologically implausible weight, height, or BMI values (eg, height <4 ft or ≥8 ft, weight <50 lb or ≥1000 lb, BMI <5 or ≥90 kg/m^2).

We categorized individuals as overweight (25.0–29.9 kg/m^2), obese class 1 (30.0–34.9 kg/m^2), obese class 2 (35.0–39.9 kg/

TABLE 1 Characteristics of the PORTAL Obesity Cohort of overweight or obese individuals by diagnosed hypertension prevalence, age categories, weight categories, and neighborhood education quartiles

No. (%)	Total	Black	American Indian/ Alaskan Native	Asian	Hispanic	Native Hawaiian/ other Pacific Islander	White
Total	N = 4 060 585 (100)	N = 463 778 (11.4)	N = 23 359 (0.6)	N = 531 363 (13.1)	N = 1 008 415 (24.8)	N = 59 763 (1.5)	N = 1 973 907 (48.6)
Hypertension prevalence	1 498 328 (36.9)	219 510 (47.3)	8942 (38.3)	185 164 (34.8)	279 301 (27.7)	23 067 (38.6)	782 344 (39.6)
Age category, y							
20–29	509 881 (12.6)	62 895 (13.6)	2617 (11.2)	69 690 (13.1)	176 709 (17.5)	10 284 (17.2)	187 686 (9.5)
30–39	600 576 (14.8)	63 003 (13.6)	3231 (13.8)	94 103 (17.7)	200 851 (19.9)	11 267 (18.9)	228 121 (11.6)
40–49	777 828 (19.1)	98 098 (21.1)	4600 (19.7)	109 629 (20.6)	232 723 (23.1)	12 658 (21.2)	320 120 (16.2)
50–59	884 526 (21.8)	109 534 (23.6)	5688 (24.4)	108 873 (20.5)	198 873 (19.7)	12 084 (20.2)	449 474 (22.8)
60–69	728 062 (17.9)	76 504 (16.5)	4585 (19.6)	86 908 (16.4)	119 177 (11.8)	8333 (13.9)	432 555 (21.9)
70–79	383 029 (9.4)	39 270 (8.5)	2013 (8.6)	43 213 (8.1)	57 710 (5.8)	3902 (6.5)	236 921 (12.0)
80+	176 683 (4.4)	14 474 (3.1)	625 (2.7)	18 947 (3.6)	22 372 (2.2)	1235 (2.1)	119 030 (6.0)
Weight category							
Overweight	2 052 978 (50.6)	188 501 (40.6)	9998 (42.8)	335 982 (63.2)	475 194 (47.1)	26 704 (44.7)	1 016 599 (51.5)
Obesity class 1	1 179 346 (29.0)	140 094 (30.2)	6943 (29.7)	142 250 (26.8)	314 869 (31.2)	16 744 (28.0)	558 446 (28.3)
Obesity class 2	500 187 (12.3)	74 005 (16)	3646 (15.6)	38 295 (7.2)	135 301 (13.4)	8823 (14.8)	240 117 (12.2)
Obesity class 3	328 074 (8.1)	61 178 (13.2)	2772 (11.9)	14 836 (2.8)	83 051 (8.3)	7492 (12.5)	158 745 (8.0)
Neighborhood education category							
<23% high school or lower (highest education level)	1 023 255 (25.2)	77 648 (16.7)	5428 (23.3)	173 411 (32.6)	111 899 (11.1)	9198 (15.4)	645 671 (32.7)
23%–35.9% high school or lower	1 005 187 (24.8)	108 539 (23.4)	6267 (26.8)	138 701 (26.1)	164 754 (16.3)	14 897 (24.9)	572 029 (29.0)
3 6%–50.9% high school or lower	1 003 903 (24.7)	133 023 (28.7)	6645 (28.4)	127 071 (23.9)	243 299 (24.1)	17 808 (29.8)	476 057 (24.1)
>51% high school or lower (lowest education level)	1 028 240 (25.3)	144 568 (31.2)	5019 (21.5)	92 180 (17.4)	488 463 (48.5)	17 860 (29.9)	280 150 (14.2)

For non-Asians: overweight (25.0–29.9 kg/m^2), obese class 1 (30.0–34.9 kg/m^2), obese class 2 (35.0–39.9 kg/m^2), and obese class 3 (≥40 kg/m^2). For Asians: overweight (23.0–27.4 kg/m^2), obesity class 1 (27.5–32.4 kg/m^2), obesity class 2 (32.5–37.4 kg/m^2), and obesity class 3 (≥37.5 kg/m^2).

m^2), and obese class 3 (≥40 kg/m^2).[19] For Asians, we employed the World Health Organization's recommended cut points for Asians for overweight (23.0–27.4 kg/m^2), obesity class 1 (27.5–32.4 kg/m^2), obesity class 2 (32.5–37.4 kg/m^2), and obesity class 3 (≥37.5 kg/m^2) classifications.[17]

2.3 | Race/ethnicity

Race/ethnicity was obtained from health plan administrative records, documentation during a healthcare encounter, or from birth certificates (if applicable). Individuals had the option to identify themselves as Asian, black or African American, Hispanic, Native Hawaiian or other Pacific Islander, American Indian or Alaskan Native, white, or other. If self-identified as Hispanic, the individual was placed in that category regardless of race. If the information was not available or individuals identified themselves as belonging to another race/ethnic group, they were excluded from these analyses (204 091 or 5% of the cohort; mostly missing information).

2.4 | Neighborhood education

Neighborhood education was estimated using geospatial entity object codes (geocodes) that linked addresses to 2010 US Census data at the block group level with addresses as listed in the electronic health record. Each individual was assigned the probability of having a high school or lower education based on the percentage with high school or lower education levels in his/her neighborhood block group. These probabilities were divided into quartiles based on the study distribution: <23% high school or lower (highest education level), 23% to 35.9%, 36% to 50.9%, and >51% (lowest education level). Adults with missing census block group education were excluded from the analyses (133 679 or 3% of the cohort).

2.5 | Statisitcal analysis

Diagnosis of hypertension and demographic characteristics, age in 10-year intervals, weight category, and neighborhood education quartile were summarized as absolute numbers and proportions and reported by race/ethnicity. Unadjusted bar plots displaying hypertension prevalence for neighborhood education levels within each race/ethnicity by weight category are presented to display overall trends. In initial analyses, we stratified by sex. Similar associations were found; therefore, final analyses combined sexes to simplify interpretations. Logistic regression, adjusted for weight category, neighborhood education level, age, sex, and site, was used to estimate odds ratios (ORs) and 95% confidence intervals for the association between hypertension and race/ethnicity, with whites as the reference group. To understand how the association between hypertension prevalence and race/ethnicity might be modified by weight category and neighborhood education level, we tested two- and three-way interactions with these variables and race/ethnicity. Results presented used weight categories for Asians recommended by the World Health Organization.[17] Standard cut points were used for other race/ethnicities. We also examined standard BMI cut points for Asians, with similar associations as reported below. Adjusted prevalence rates of hypertension were estimated using marginal standardization of predicted probabilities from these models and 95% confidence intervals were obtained using 200 bootstrapped estimates. All statistical analyses were conducted using SAS version 9.3 (SAS Institute, Inc) and R version 3.3.0.

3 | RESULTS

We identified 4 060 585 adults from the PORTAL cohort who were overweight or obese. Approximately 50% of the adults were white, 25% were Hispanic, 13% were Asian, 11% were black, 1.5% were Native Hawaiian/other Pacific Islander, and 0.6% were American Indian/Alaskan Native (Table 1). Most individuals were in the 40- to 49- and 50- to 59-year age categories. Within racial/ethnic groups, Asians and whites were more likely to be categorized as overweight, whereas obesity class 3 was most prevalent among blacks, Native Hawaiians/other Pacific Islanders, and American Indians/Alaskan Natives. Neighborhood education prevalence varied by race/ethnicity, with whites and Asians having the highest proportion of adults living in the highest neighborhood education category (about 33%) and Hispanics, blacks, and Native Hawaiian/other Pacific Islander having the highest prevalence of living in the lowest neighborhood education category.

The Figure illustrates the unadjusted prevalence of hypertension within overweight/obese weight categories by race/ethnicity and neighborhood education category. Across all race/ethnicities, the prevalence of hypertension was markedly higher at higher weight categories. For adults who were overweight and obese class I, we observed a stair-step pattern within each race/ethnicity indicating higher hypertension prevalence at lower neighborhood education categories for all race/ethnicities except for Hispanics. This trend was not observed in adults with obesity class 2 or class 3. In contrast, for Hispanics, hypertension prevalence was lower at successive lower neighborhood education categories in the obese class 1, 2, and 3 categories.

A diagnosis of hypertension was documented for 36.9% of overweight or obese adults. Table 1 displays the unadjusted prevalence of hypertension across race/ethnicity categories. Hypertension prevalence was highest among blacks at 47.3% and lowest among Hispanics at 27.7%. Standardized prevalence ratios accounting for age, sex, healthcare organization, and either weight category or neighborhood education category are displayed in Table 2. Hypertension prevalence was 5% to 10% higher at each successive increase in overweight/obese weight category for all race/ethnicities. In contrast, after accounting for age, sex, site, and weight category differences, hypertension prevalence remained fairly stable within racial/ethnic categories at all levels of neighborhood education (Table 2).

Table 3 presents overall adjusted ORs for hypertension among the overweight or obese cohort. Compared with whites, the odds for hypertension in blacks were doubled, in Native Hawaiians/other Pacific Islanders were 85% greater, in Asians were 42% greater, and

TABLE 2 Age-standardized diagnosed hypertension prevalence ratios and 95% confidence intervals by race/ethnicity, weight class, and neighborhood education quartile

	No.	Black	American Indian/ Alaskan Native	Asian	Hispanic	Native Hawaiian/other Pacific Islander	White
Overall	4 060 585	46.0 (45.9–46.2)	37.3 (36.9–37.8)	40.4 (40.3–40.5)	34.3 (34.2–34.4)	44.7 (44.3–45.0)	34.9 (34.9–35.0)
Weight class							
Overweight	2 052 978	41.3 (41.1–41.5)	31.3 (30.6–32.0)	33.9 (33.8–34.1)	29.4 (29.3–29.5)	40.5 (40.0–41.0)	29.2 (29.1–29.2)
Obesity class 1	1 179 346	48.9 (48.6–49.1)	39.8 (38.6–40.8)	43.8 (43.6–44.0)	36.3 (36.2–36.5)	47.1 (46.6–47.7)	37.6 (37.5–37.7)
Obesity class 2	500 187	53.4 (53.1–53.7)	45.8 (44.1–47.1)	50.7 (50.2–51.1)	41.4 (41.1–41.6)	51.2 (50.0–52.2)	43.3 (43.1–43.5)
Obesity class 3	328 074	58.3 (57.9–58.6)	51.5 (50.0–53.0)	55.8 (55.1–56.4)	46.9 (46.6–47.2)	54.2 (53.2–55.2)	48.9 (48.7–49.2)
Neighborhood education							
<23% high school or lower (highest education level)	1 023 255	45.5 (45.2–45.7)	36.6 (35.4–37.5)	38.6 (38.5–38.8)	34.6 (34.3–34.9)	44.6 (43.6–45.4)	33.7 (33.6–33.9)
23%-35.9% high school or lower	1 005 187	46.8 (46.6–47.1)	37.6 (36.6–38.7)	41.5 (41.3–41.8)	35.8 (35.5–36.0)	46.1 (45.2–46.8)	35.5 (35.4–35.6)
36%-50.9% high school or lower	1 003 903	46.9 (46.6–47.1)	38.6 (37.4–39.6)	42.0 (41.8–42.2)	35.4 (35.2–35.6)	45.6 (45.0–46.2)	36.1 (35.9–36.2)
>51% high school or lower (lowest education level)	1 028 240	45.0 (44.7–45.2)	36.3 (35.1–37.4)	39.6 (39.3–39.8)	33.1 (32.0–33.2)	42.9 (42.2–43.5)	34.7 (34.6–34.9)

For non-Asians: overweight (25.0–29.9 kg/m^2), obese class 1 (30.0–34.9 kg/m^2), obese class 2 (35.0–39.9 kg/m^2), and obese class 3 (≥40 kg/m^2). For Asians: overweight (23.0–27.4 kg/m^2), obesity class 1 (27.5–32.4 kg/m^2), obesity class 2 (32.5–37.4 kg/m^2), and obesity class 3 (≥37.5 kg/m^2).

TABLE 3 Age, healthcare organization, and sex-adjusted odds ratios and 95% confidence intervals for diagnosed hypertension prevalence overall and within weight class and neighborhood education quartile compared with whites

	No.	Black	American Indian/ Alaskan Native	Asian	Hispanic	Native Hawaiian/ other Pacific Islander	White
Overall	4 060 585	2.02 (2.00–2.03)	1.17 (1.13–1.20)	1.42 (1.41–1.43)	0.96 (0.95–0.97)	1.85 (1.81–1.90)	Reference
Weight class							
Overweight	2 052 978	2.27 (2.24–2.3)	1.17 (1.11–1.23)	1.39 (1.38–1.41)	1.02 (1.01–1.03)	2.15 (2.08–2.22)	Reference
Obesity class 1	1 179 346	1.96 (1.93–1.99)	1.14 (1.08–1.21)	1.45 (1.43–1.47)	0.92 (0.91–0.93)	1.77 (1.70–1.84)	Reference
Obesity class 2	500 187	1.81 (1.77–1.85)	1.16 (1.07–1.25)	1.54 (1.50–1.58)	0.90 (0.88–0.91)	1.59 (1.50–1.69)	Reference
Obesity class 3	328 074	1.71 (1.67–1.75)	1.16 (1.06–1.26)	1.48 (1.42–1.54)	0.89 (0.87–0.91)	1.35 (1.27–1.44)	Reference
Neighborhood education							
<23% high school or lower (highest education level)	1 023 255	2.08 (2.04–2.12)	1.19 (1.12–1.28)	1.36 (1.34–1.38)	1.06 (1.04–1.07)	1.97 (1.87–2.08)	Reference
23%–35.9% high school or lower	1 005 187	2.02 (1.99–2.06)	1.15 (1.08–1.22)	1.46 (1.44–1.48)	1.02 (1.00–1.03)	1.93 (1.85–2.01)	Reference
36%–50.9% high school or lower	1 003 903	1.98 (1.95–2.01)	1.18 (1.11–1.25)	1.46 (1.43–1.48)	0.96 (0.94–0.97)	1.82 (1.75–1.90)	Reference
>51% high school or lower (lowest education level)	1 028 240	1.96 (1.92–1.99)	1.11 (1.04–1.19)	1.38 (1.35–1.40)	0.90 (0.88–0.91)	1.71 (1.64–1.78)	Reference

For non-Asians: overweight (25.0–29.9 kg/m^2), obese class 1 (30.0–34.9 kg/m^2), obese class 2 (35.0–39.9 kg/m^2), and obese class 3 (≥40 kg/m^2). For Asians: overweight (23.0–27.4 kg/m^2), obesity class 1 (27.5–32.4 kg/m^2), obesity class 2 (32.5–37.4 kg/m^2), and obesity class 3 (≥37.5 kg/m^2).

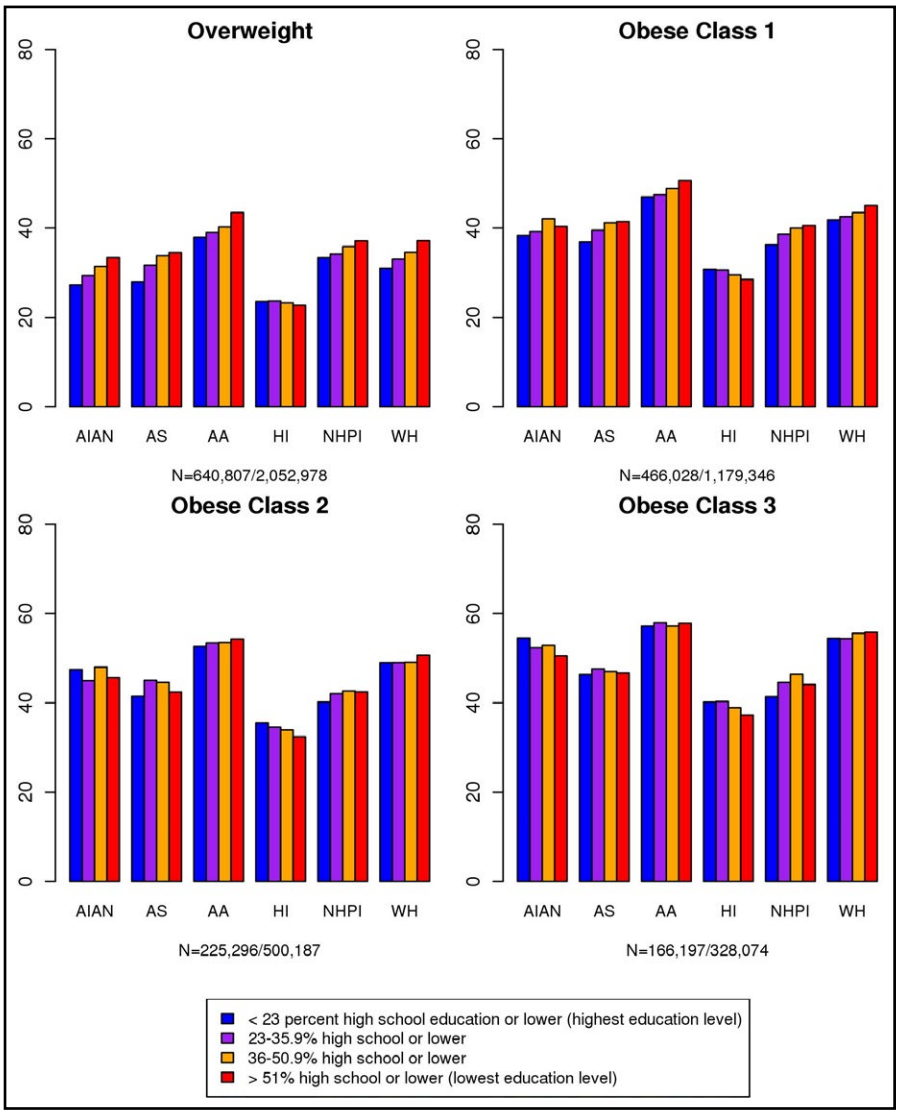

FIGURE Unadjusted prevalence of diagnosed hypertension of overweight or obese adults within weight class and neighborhood education level. For non-Asians: overweight (25.0–29.9 kg/m^2), obese class 1 (30.0–34.9 kg/m^2), obese class 2 (35.0–39.9 kg/m^2), and obese class 3 (≥40 kg/m^2). For Asians: overweight (23.0–27.4 kg/m^2), obesity class 1 (27.5–32.4 kg/m^2), obesity class 2 (32.5–37.4 kg/m^2), and obesity class 3 (≥37.5 kg/m^2). AIAN indicates American Indian/Alaskan Native; AS, Asian; AA, black; HI; Hispanic; NHPI; Native Hawaiian/other Pacific Islander; WH, white

in American Indians/Alaskan Natives were 17% greater. In contrast, Hispanics had 4% lower odds of hypertension compared with whites.

Two-way interactions were significant between race/ethnicity and both weight and neighborhood education category ($P < .0001$ for both), indicating that these variables modified the association of race/ethnicity with hypertension prevalence. As displayed in Table 3, across most weight categories, the magnitude of hypertension odds, compared with whites, was the greatest for blacks and Native Hawaiians/other Pacific Islanders, and more than double that of whites in the overweight category. Compared with whites, the odds of hypertension among American Indian/Alaskan Natives were elevated by approximately 15% across weight categories and about 40% to 54% greater for Asians across weight categories. Hispanics in the overweight category had slightly but significantly higher odds of hypertension compared with whites but lower odds at the obese weight categories (Table 3).

At all neighborhood education levels, the odds of hypertension were doubled for blacks compared with whites, with that in Native Hawaiians/other Pacific Islanders at a comparable magnitude (Table 3). American Indians/Alaskan Natives had hypertension odds that were about 20% greater than whites across neighborhood education categories. Asians had odds that were between 36% and 46% greater than whites. (Table 3).

We tested for a three-way interaction for hypertension prevalence across race/ethnicity within overweight and obese weight categories and within neighborhood education categories, with whites in a specific neighborhood education level as the reference. The three-way interaction was not significant, implying that the noted associations did not differ by neighborhood education within weight category (Table S1).

4 | DISCUSSION

In this large, racially/ethnically and geographically diverse overweight and obese sample, we found that all racial and ethnic minorities, except Hispanics, had higher odds of diagnosed hypertension prevalence across all weight categories and neighborhood education levels

compared with whites. In general, although tests for two-way interactions were significant, compared with whites, the magnitude of the odds of hypertension for each racial/ethnic category compared with whites did not substantially vary based on overweight/obese weight category or neighborhood education category. Our results suggest that these factors may not explain the racial/ethnic disparities in hypertension prevalence compared with whites.

Previous studies have not compared hypertension disparities in weight categories across multiple race categories in geographically diverse samples; thus, our results shed new light on the pervasiveness of race/ethnic disparities in hypertension. Persistent hypertension prevalence disparities across weight categories between blacks and whites[9,10,20] and between Asians and whites[11] were reported, although differences in study designs do not allow direct comparisons between these previous results and ours. Nonetheless, our results extend the noted disparities to Native Hawaiians/other Pacific Islanders and American Indians/Alaskan Natives.

Higher odds of hypertension among blacks, American Indians/Alaskan Natives, Asians, and Native Hawaiians/other Pacific Islanders across overweight/obese weight categories compared with whites may be attributable to differences in body composition within a given weight category across race/ethnicities. The association between BMI and percent body fat differs by race/ethnicity.[17,21] Blacks have greater prevalence rates of abdominal obesity than whites and Hispanics, and abdominal obesity is associated with greater odds of hypertension even after controlling for BMI and other covariates.[22] Further, Asians have greater central adiposity at a given BMI level compared with Europeans.[23] While our study precluded assessment of percent body fat or waist circumference, this may partially explain some of our results.

We observed that Hispanics living in the two lowest neighborhood education categories had lower odds of hypertension compared with whites. Approximately 70% of Hispanics in the cohort lived in these neighborhoods. It is possible that the low education neighborhoods in our study had a higher proportion of Hispanics living in them than in the higher education neighborhoods. Previous research suggests that living in Hispanic enclaves may be protective from incident cardiovascular disease[24] and all-cause mortality.[25] Social and cultural advantages of living in ethnically congruent neighborhoods may counteract the disadvantages of having low SES, particularly for Hispanics.[24,25]

Neighborhoods with the same educational category are likely to vary in terms of neighborhood amenities depending on their racial composition. For instance, predominantly black neighborhoods have greater levels of disadvantage regardless of SES.[8] Disadvantaged minority neighborhoods usually have less access to healthy foods and recreational facilities and excess advertising for products that can influence blood pressure.[26,27] Further, discrimination has been shown to affect minority health, regardless of an individual's SES.[28] Living in neighborhoods with higher SES that are also more likely to have a higher proportion of whites may expose minorities to more discrimination because of more contact with whites.[28,29] Discrimination can increase chronic stress, which is associated with hypertension.[30] Discrimination experienced in residential neighborhoods may impact the health of minority race/ethnicities differentially, with possibly a lesser influence on Hispanics.

5 | STUDY STRENGTHS AND LIMITATIONS

Much previous work in race/ethnicity, SES, and health outcomes has documented disparities between blacks, Hispanics, and whites.[31–33] Our large and diverse sample allows us to expand those findings by documenting hypertension diagnosis disparities among Asians, American Indians/Alaskan Natives, and Native Hawaiian/other Pacific Islanders. We are not aware of many other studies that have made similar observations. One study found that Asians in the highest individual-level education or income category had lower hypertension prevalence than whites,[34] although another did not find similar results.[12] A study that included American Indians found higher hypertension prevalence rates across all SES categories compared with whites.[34]

While our cohort was large and represented most regions of the United States, it is not representative of the entire US population. Most (except those from Denver Health) were insured and all had to have an outpatient office visit in 2012–2013 to be included in the study. Healthy people may be less likely to visit their healthcare providers, so the cohort may be less healthy than the total insured population, and estimates of hypertension may be inflated. Hypertension prevalence was defined by diagnosis coding, which misses those who may have undiagnosed hypertension. Individual SES was not available, and neighborhood education level and individual SES, while correlated, are different constructs.[30] Most Hispanics in the cohort came from California and may not be representative of Hispanics across the country. We were unable to separate Asians and Hispanics into their country of origin and hypertension prevalence may vary by Asian or Hispanic ethnicity.

Notwithstanding these limitations, the study has several strengths. The cohort size and racial/ethnic diversity allowed for precise estimates of hypertension odds compared with whites among population subgroups that are rarely able to be compared. For instance, while data on hypertension prevalence among American Indians/Alaskan Natives compared with whites are inconsistent,[35,36] we were able to document increased odds with narrow confidence intervals. Similarly, the results we presented for Native Hawaiians/other Pacific Islanders are unprecedented.

6 | CONCLUSIONS

We documented that among adult members of 10 different healthcare systems with a diagnosis of hypertension, rates of prevalence are significantly greater for blacks, American Indians/Alaskan Native, Asians, and Native Hawaiians/other Pacific Islanders than for whites and lower for Hispanics even in similar weight categories and neighborhood SES levels. Disparities remain across weight class and neighborhood education level, suggesting that other factors might be driving

forces of racial/ethnic disparities in hypertension. More research is needed to understand the many factors that may contribute to the variation in hypertension prevalence across racial/ethnic groups.

FINANCIAL DISCLOSURE

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AUTHORS' CONTRIBUTIONS

Dr Young drafted the article, Dr Fischer contributed to drafting the analysis portion of the article, and each of the authors participated in conceiving the research question, designing the analysis, contributing data, reviewing and making critical revisions, and approving the final article.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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