REVIEW

Racial-Ethnic Disparities in Obesity and Biological, Behavioral, and Sociocultural Influences in the United States: A Systematic Review

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ABSTRACT

For a comprehensive understanding of high-level obesity in the USA, we studied the trends of obesity prevalence since 2007, and related biological, behavioral, and sociocultural factors in obesity racial/ethnic disparities. We searched PubMed, Embase, and national data archives for the studies using national survey data and published in English from January 1, 2007 to September 11, 2020. Forty-seven studies met the inclusion criteria and were systematically reviewed. After a short leveling-off during 2009–2012, the US national prevalence of obesity has steadily increased. Although women had higher racial/ethnic disparities in obesity and severe obesity than men, it decreased due to the significant drop in non-Hispanic black (NHB) women in the last 10 y. However, obesity and severe obesity prevalence increased in Mexican-American (MA) men, MA boys, and MA girls and became similar to or surpassing NHB groups. Substantial racial/ethnic disparities remained in the past decade. Even at the same level of BMI, MAs and non-Hispanic Asians had a higher percent of body fat and metabolic syndrome than other ethnic/racial groups. NHB's cultural preference for a large body significantly associated weight misperception and lower weight control practices. In addition to socioeconomic status, health behaviors, neighborhood environments, and early childhood health factors explained substantial racial/ethnic differences in obesity. Differences in biological, behavioral, and sociocultural characteristics should be considered in future public health intervention efforts to combat obesity in the USA. *Adv Nutr* 2021;12:1137–1148.

Keywords: race, ethnicity, disparities, obesity, the United States

Introduction

Beginning in 1970, obesity prevalence in the USA increased rapidly (1), with about half the adult population projected to have obesity by 2030 (2). In addition, significant disparities in obesity have been observed across sex, age, race/ethnicity, socioeconomic status (SES), and neighborhood environments (3–5). Although some studies reported stable US obesity trends in the early 2010s, other studies found that not all groups experienced the positive changes from national initiatives for better nutritional environments in early childhood care and education, schools, worksites, and communities (1). As Healthy People 2030 aimed to eliminate health disparities and improve the health of all groups (6), a comprehensive understanding of the patterns and underlying mechanisms of obesity was necessary to develop effective public health interventions.

Behavioral characteristics explained about one-third of the health disparities across race/ethnicity. The difference in hazard rates in cardiovascular mortality between non-Hispanic blacks (NHBs) and non-Hispanic whites (NHWs) was reduced by 59% after adjusting for substance abuse, dietary factors, physical activity, and cigarette smoking (7, 8). Heavy consumption of sugar-sweetened beverages (SSBs) was prevalent in NHB and Hispanic individuals, whereas a low level of exercise was common among the Hispanic population, and excessive screen time was prevalent in NHB individuals (9, 10). Underlying differences in SES indicators, such as low levels of household income and education and unsafe neighborhoods, were also associated with

This work was supported by the US NIH, the Eunice Kennedy Shriver National Institute of Child Health & Human Development [1R01HD064685-01A1]. The content of the article is solely the responsibility of the authors and does not necessarily represent the official views of the funders.
Author disclosures: The authors report no conflicts of interest.
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Abbreviations used: MA, Mexican American; MeSH, Medical Subject Headings; NHA, non-Hispanic Asian; NHB, non-Hispanic black; NHW, non-Hispanic white; SES, socioeconomic status; SSB, sugar-sweetened beverage.

 Adv Nutr 2021;12:1137–1148; doi: https://doi.org/10.1093/advances/nmaa162.

racial/ethnic disparities in health behaviors. Since poverty and unemployment rates in the NHB group were twice as high as those of the NHW group (11), NHB individuals may face more challenges in implementing healthy diets and enough physical activity in a safe neighborhood.

Some studies suggested that a higher rate of weight misperception and a lower rate of weight loss attempts among NHB individuals may be caused by the preference of larger body shape and size and less concern about obesity than other groups (12). Obesity could have a less negative association with self-esteem and body dissatisfaction among NHB adolescents than for white peers (13). In contrast, Hispanic and non-Hispanic Asian (NHA) children were more likely to be dissatisfied with their bodies than NHWs (13), which also caused higher BMI increases over time among children with obesity due to low self-esteem from weight stigma (14, 15).

Besides the influences of ethnic culture in weight perception and preference, considerable discussion has addressed varied BMI-adiposity relations across racial/ethnic groups (16). In 2004, the WHO expert committee recommended lower BMI cut-offs for obesity among Asians since they have a higher percent of body fat and increased cardiovascular risk factors at a given BMI than Europeans (17).

These findings suggest that further comprehensive research is necessary to assess racial/ethnic disparities of obesity in the USA. However, thus far, no review has examined obesity disparities in the USA with a holistic and comprehensive view that includes sex and racial/ethnic differences in biological, cultural, and socioenvironmental characteristics. This study aimed to bridge this research gap by *1*) describing sex and racial/ethnic variations in obesity prevalence in the USA over the past decade since 2007, after our previous 2007 published systematic review (1), and *2*) thoroughly exploring which factors may have contributed to the variation in the USA. We investigated potential key contributing factors to racial/ethnic disparities in US obesity prevalence, including: *1*) biological differences in the level of body fat and metabolic risk at a given BMI, *2*) cultural differences in body image and related weight loss attempts among ethnic groups, and *3*) the role of individual SES, health behaviors, and neighborhood characteristics in obesity disparities across race/ethnicity.

Methods

Literature search strategy, data extraction, and analysis

We included 2 parts of the literature search to *1*) describe racial/ethnic disparities in obesity prevalence and *2*) examine related contributing factors.

Part I. Sex and racial/ethnic disparities in obesity and severe obesity.

The authors searched studies published from 1 January, 2007 through to 11 September, 2020 in PubMed, Embase, and the National Center for Health Statistics (NCHS) Health E-Stats. The initial search, with search terms below with the combination of Medical Subject Headings (MeSH) and Title and Abstract headings, yielded 641 articles. Key search terms included: “United States,” “obesity,” “overweight,” “body mass index,” “race,” “ethnicity,” and the name of nationally representative data sets “National Health and Nutrition Examination Surveys (NHANES),” “Behavioral Risk Factor Surveillance System (BRFSS),” “Youth Risk Behavior Surveillance System (YRBSS),” “Early Childhood Longitudinal Study (ECLS),” and “National Longitudinal Survey Adolescent Health (NLSAH)” to observe overall sex and racial/ethnic disparities in obesity in the USA. Next, we expanded our search using a similar article link and found an additional 306 articles. After the title and abstract screening of 947 articles, 69 articles were selected for full-text screening.

Of those 69 articles, 23 articles met our inclusion criteria: *1*) published in 2007 and after, 2) reporting a prevalence of either obesity or severe obesity for adults or children, *3*) using nationally representative data sets, *4*) comparing racial/ethnic difference in obesity, and *5*) publishing in English. We used 9 articles with NHANES data to describe sex and racial/ethnic-specific prevalence after considering the overlap of study periods, comparable categories of subject characteristics (e.g. a combined group of age and race/ethnicity), and major obesity outcomes available in the 23 articles.

Data were extracted and arranged following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines into a standardized data extraction form by 2 investigators. Information extracted included the publication year, study setting, study subjects’ demographics, the prevalence of obesity and severe obesity, and contributing factors in racial/ethnic disparities in obesity.

In our review, as did most of the publications using NHANES data, obesity and severe obesity were classified as BMI $\geq$30 and $\geq$40 kg/m^2 in adults (18, 19), and BMI $\geq$95th percentile, and BMI $\geq$120% of the 95th percentile, or BMI $\geq$35, whichever was lower in children using the age-sex-specific BMI percentile in the 2000 CDC growth charts (20, 21), respectively. Race/ethnic group was defined as NHWs, NHBs, Hispanics (including Mexican Americans and other Hispanics), Mexican Americans (MAs), NHAs, and Others (non-Hispanic persons reported races other than black or white). Limited data were available for Hispanic, MA, NHA, and Other groups across years. To describe racial/ethnic disparities in obesity, we used ethnic ratios comparing the highest prevalence to that for NHWs in each sex-age-specific group.

Part II. Potential contributing factors to racial/ethnic disparities in obesity.

To define the studies examining contributing factors in obesity disparities, we conducted a systematic review, in addition to the 69 selected published articles/reports mentioned above. The initial search terms included “race,” “ethnicity,” “sex,” “obesity,” “disparities,” “difference,” “United States,” and alternatives with the combination of MeSH and Title and Abstract headings in PubMed and Embase. Two coauthors performed full-text screening for eligibility. In total, 24 studies were included in the review, which met the following inclusion criteria: *1*) comparing the level of contributing factors of obesity (e.g. body fat, metabolic risk, body image, weight perception, attempt for weight control) across race/ethnicity or examining how much racial/ethnic disparities in obesity can be explained by SES, health behaviors, neighborhood environments, *2*) using quantitative analysis, *3*) not using convenience samples with small sample size, and *4*) including diverse ethnic groups rather than targeting 1 ethnic group.

To examine the contributing roles of SES, health behaviors, and neighborhood characteristics in obesity disparities across race/ethnicity, we assessed the percent change in each point estimate (i.e. higher BMI level, presented by ß in linear regression models or risk of obesity, presented by OR in logistic regression models in racial/ethnic minority compared with NHWs) obtained before and after adjustment (22). The percent change indicates the mediating role of the individual, household, and neighborhood characteristics on obesity disparities across race/ethnicity. We set the reference cut-off to define a significant mediation effect by calculating the median percent changes (19%) across selected studies.

Study quality assessment

We used the NIH quality assessment tool for observational cohort and cross-sectional studies to assess the quality of each included study using 14 criteria according to the study characteristics. For each criterion, a score of 1 was assigned if "yes" was the response, whereas "0" was assigned otherwise (i.e. an answer of "no," "not applicable," "not reported," or "cannot determine"). A study-specific global score, ranging from 0 to 14 (a higher score indicates a better rank than a lower score), was calculated by summing scores across all criteria (23). This quality assessment helped describe the strength of the scientific evidence but was not used to determine inclusion of a study. Overall, 61% of selected articles conducted complete case analysis without imputation, 9% carried out imputation, and 30% did not report how they handled missing data.

Statistical analysis

To estimate the pooled prevalence in obesity for age-, sex-, year-specific subgroups, meta-analyses were conducted using STATA (version 16.0). The random-effects meta-analysis model was chosen to take account of between-study heterogeneity of the included studies, so the summary effect was a mean estimate of all effects. A test for heterogeneity was applied using I^2 statistics. All I^2 statistics were $<30\%$, indicating not important(24).

Results

Sex and racial/ethnic-specific pooled prevalence of obesity and severe obesity among US adults and children

In general, obesity and severe obesity prevalence increased between 2007 and 2016, with a short leveling-off between 2009 and 2012. Women maintained a higher prevalence than males in the last 10 y. Men had more considerable annual increase in obesity [β (SE) = 0.61 (0.10) compared with 0.47 (0.11)], whereas women had a higher increase in severe obesity [β (SE) = 0.17 (0.04) compared with 0.22 (0.06)] (2).

Sex-specifically, women had higher ranges in the racial/ethnic disparities than men (**Figure 1**). Although NHB women maintained a higher prevalence than other ethnic groups, they had dramatic decreases in obesity (58.7% in 2009–2010 compared with 54.8% in 2015–2016) and severe obesity (18.0% in 2009–2010 compared with 14.3% in 2015–2016). These results led to an observed leveling of overall prevalence. However, other racial/ethnic women had a steadily increasing prevalence throughout the study period. Consequently, the racial/ethnic ratios for women decreased in the last 10 y (e.g. 2.3:1 in 2007–2008 compared with 1.6:1 in 2015–2016 for severe obesity).

In contrast, for men, the MA group surpassed the NHB group and became the highest in obesity prevalence since 2011–2012. The racial/ethnic ratios for men remained at similar obesity levels (e.g. 1.2:1 in 2007–2008 and 2015–2016).

Boys recently had higher racial/ethnic disparities in both obesity and severe obesity than before due to the steep increase in the MA group compared to no significant difference in other racial/ethnic groups during the study period. In contrast, NHB girls and MA girls took turns to be the highest in obesity and severe obesity. The increase of racial/ethnic disparities in severe obesity between 2007 and 2017 was more apparent than obesity in children.

Ethnic differences in body fat and metabolic risk at a given BMI

The 5 selected articles focused mostly on children (25–29) and analyzed percent of body fat, visceral adipose tissue, fat mass, skinfolds and waist circumference (WC), and prevalence of metabolic syndrome in addition to BMI or weight status defined by BMI. The level of adiposity and metabolic risk at a given BMI and weight status was not uniform across racial/ethnic groups (**Table 1**).

First, NHB children showed consistently lower levels in the percent of body fat (~2–4%) (26, 27), the volume of visceral adipose tissue (i.e. 30 mL) (25), the sum of skinfolds (i.e. 5.2 cm) and WC (i.e. 1.9 cm) (28) than NHW and MA children in 3 studies. The low level of adiposity among NHB children remained even after adjusting for BMI and age, and regardless of weight status (26, 28). Even across weight categories, NHB boys consistently had a lower percent of body fat than NHW or MA boys in normal (17.4% compared with 20.2% and 20.7%) and overweight categories (24.8% compared with 28.2% and 28.8%).

In contrast, MA children (26, 27) and NHA adults (29) had a higher prevalence of adiposity and metabolic syndrome at the same BMI level after adjusting for weight status than NHB and NHW counterparts in 3 studies; the comparison between MAs and NHAs was not examined. MA children had ~2–3% higher percent of body fat than NHW and NHB children at a given BMI. The difference in body fat between

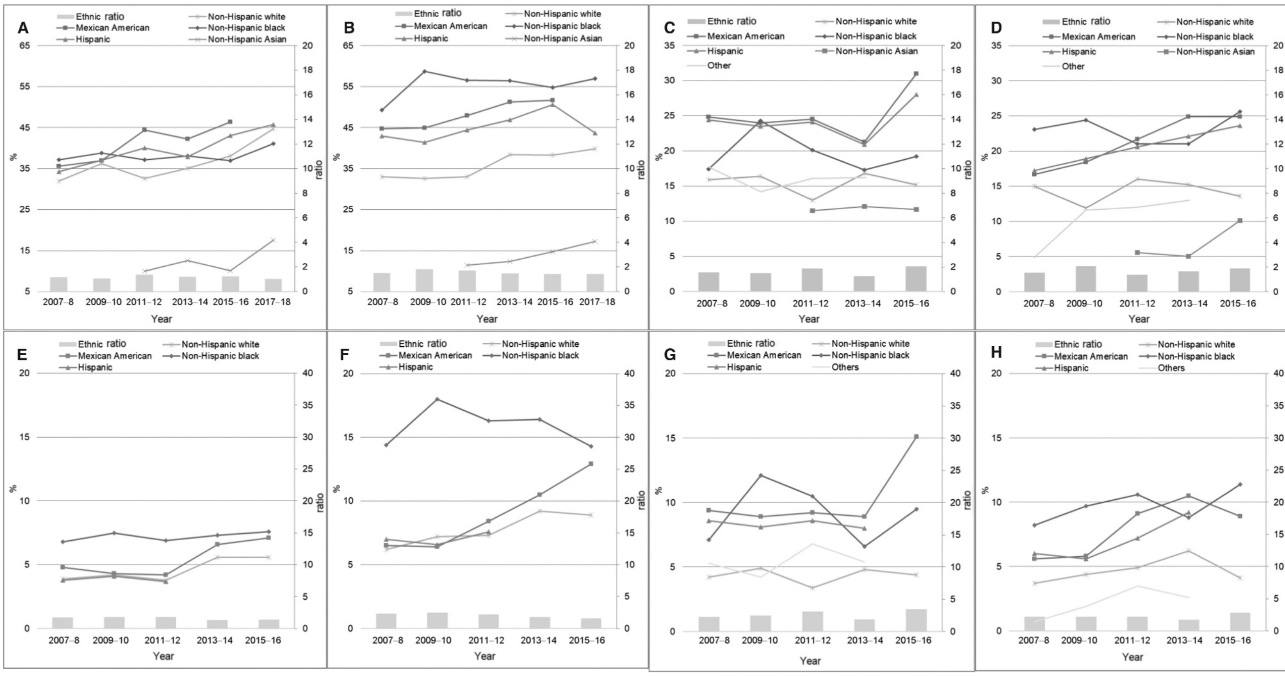

FIGURE 1 Sex- and racial/ethnic-specific prevalence of obesity and severe obesity among US adults (aged 20 y and older) and children (aged 2–19 y) based on data from NHANES 2007–2016 in 9 studies (2, 30–37). A) Adult obesity – men. B) Adult obesity – women. C) Child obesity – boys. D) Child obesity – girls. E) Adult severe obesity – men. F) Adult severe obesity – women. G) Child severe obesity – boys. H) Child severe obesity – girls. Racial/ethnic group was defined as NHWs, NHBs, Hispanics (including Mexican Americans and other Hispanics), Mexican Americans, NHA, and Other. Limited data were available for Hispanic, MA, NHA, and Other (non-Hispanic persons reported races other than black or white) groups across years. To describe racial/ethnic disparities in obesity, we used ethnic ratios comparing the highest prevalence to that for NHWs in each sex-age-specific group. Obesity and severe obesity were classified as BMI ≥30 and ≥40 kg/m^2 in adults, (18, 19) and BMI ≥95th percentile, and BMI ≥120% of the 95th percentile, or BMI ≥35 kg/m^2, whichever was lower using the age-sex-specific BMI percentile in the 2000 CDC growth charts (20, 21) in children, respectively. Ethnic ratios in A by year: 1.2, 1.1, 1.4, 1.2, 1.2, 1.0. Ethnic ratios in B by year: 1.5, 1.8, 1.7, 1.5, 1.4, 1.4. Ethnic ratios in C by year: 1.6, 1.5, 1.9, 1.3, 2.0. Ethnic ratios in D by year: 1.5, 2.1, 1.4, 1.6, 1.9. Ethnic ratios in E by year: 1.7, 1.8, 1.8, 1.3, 1.4. Ethnic ratios in F by year: 2.3, 2.5, 2.2, 1.8, 1.6. Ethnic ratios in G by year: 2.2, 2.5, 3.1, 1.9, 3.4. Ethnic ratios in H by year: 2.2, 2.2, 2.2, 1.7, 2.8. MA, Mexican American; NHA, non-Hispanic Asian; NHB, non-Hispanic black; NHW, non-Hispanic white.

racial/ethnic groups varied across weight status, from 1.4% in boys with obesity and 4.0% in girls with normal weight (26). At a BMI of 25, the regression model predicted the prevalence of metabolic syndrome as 43% for NHA men, but 22% for NHW men. Metabolic syndrome was even observed at a BMI of 19.6 for NHA women and 19.9 for NHA men (29).

Ethnic-specific characteristics in body perception, body dissatisfaction, and weight-control attempts

Ethnic differences in body image and body dissatisfaction existed, both in children and adults, especially in girls, in addition to weight misperception and motivation for weight loss or weight loss attempts (**Table 2**). Among adolescent females, NHBs were most likely to underperceive their weight status at 28.6% compared with Hispanics at 15.9% and NHWs at 12.9% (38). NHBs had a higher body satisfaction (believing their body size is "right") when the BMI was >90th percentile compared with others. However, the boys who perceived their appearance as "good looking" were 60% at age 11 y, but became only 30% at age 17 y (39). NHW adolescents with overweight were most likely to correctly perceive their weight status at 73.0% than Hispanics at 62.5% and NHBs at 46.6% (38). Positive body perception and small body size were associated with fewer weight loss attempts in NHW and Hispanic youth (NHW: $\beta = -0.51$, $P < 0.05$ and $\beta = 0.46$, $P < 0.05$; H: $\beta = -0.41$, $P < 0.05$ and $\beta = 0.52$, P 0.05; all SEs were not available) (40). In contrast, body size and body perception were not associated with weight loss attempts in NHB youth. Hispanic youth were significantly more likely to have overweight or obesity, have a negative perception of their body, and report more weight loss attempts than NHB and NHW youth (40).

When examining with adults, NHWs had higher body dissatisfaction and were less likely to underestimate their BMI than any other group, whereas NHBs had lower body dissatisfaction. NHB women chose smaller silhouettes than NHW women after adjusting for BMI, showing that they had a smaller self-body perception [β (SE) = −0.26 (0.09), $P < 0.01$], while also preferring a larger body (data not shown, $P <$

TABLE 1 Comparing the level of body fat and metabolic risk in different racial/ethnic groups among 5 studies conducted in the USA since 2007[1]

References	Study design	Key findings: racial/ethnic differences in body fat and metabolic risk
Children		
Harrington et al., 2013 (25)	• Survey, LA • NHB vs. NHW • 15–18 y, $n = 95$ • Visceral adipose tissue (L)[2] and fat mass (kg) vs. OB	• Although NHW and NHB girls had a significant different level of OB (9.5 vs. 32.3%) and fat mass (18.7 ± 7.9 vs. 27.0 ± 16.3 kg; all $P < 0.01$), their levels of visceral adipose tissue were similar (0.17 ± 0.14 vs. 0.18 ± 0.14, $P > 0.05$)
Dugas et al., 2011 (26)	• NHANES[3] • NHB and MA vs. NHW • 12–20 y, $n = 5622$ • Percent of body fat among normal weight and OW children	• NHBs had a lower percent of body fat (e.g. among OW boys: 24.8%) than NHWs and MAs (28.2 & 28.8%; $P < 0.001$) • MAs had a higher percent of body fat (e.g. among OW girls: 38.6%) than NHW (37.8%; $P < 0.001$)
Affuso et al., 2010 (27)	• NHANES[3] • NHB vs. NHW and MA • 13–19 y, $n = 3838$ • Percent of body fat	• NHBs had a significantly lower percent of body fat than others after controlling for weight status [e.g. the difference between NHBs vs. NHWs: boys –2.5 (0.4), girls –2.0 (0.3), all $P < 0.001$]
Sisson et al., 2009 (28)	• Survey, LA • NHB vs. NHW • 5–18 y, $n = 3218$ • Sum of skinfolds and waist circumference	• NHBs had significantly lower skinfolds (data were not shown) and WC (e.g. M: 83.1 vs. 88.3 cm, F: 82.1 vs. 84.0 cm among children with OB, all $P < 0.05$) than NHWs after adjusting for BMI and age regardless of weight status
Adults		
Palaniappan et al. 2011 (29)	• Electronic health record, CA • NHA vs. NHW • ≥35 y; $n = 43{,}507$ • Predicted prevalence of metabolic syndrome at the same BMI level	• At the mean age of 55 and BMI of 25 kg/m^2, the predicted prevalence of metabolic syndrome was higher among NHAs (M: 43%, F: 30%) vs. NHWs (M: 22%, F: 12%)

[1] All studies had a cross-sectional study design, and their global score of study quality assessment was 8. Contents were ordered by age group and publication year. Obesity and severe obesity were classified as BMI ≥30 and ≥40 kg/m^2 in adults (18, 19), and BMI ≥95th percentile, and BMI ≥120% of the 95th percentile, or BMI ≥35kg/m^2, whichever was lower using the age-sex-specific BMI percentile in the 2000 CDC growth charts (20, 21) in children, respectively.
[2] Visceral adipose tissue and fat mass were measured by MRI scans and DXA.
[3] A nationally representative sample.
F, female; L, liter; M, male; MA, Mexican American; NHA, non-Hispanic Asian; NHB, non-Hispanic black; NHW, non-Hispanic white; OW, overweight; OB, obesity; WC, waist circumference.

0.01) and reporting lower body dissatisfaction [β (SE) = –0.46 (0.08), $P < 0.01$] (41). Both NHB men and women were three times more likely to underestimate their weight status than NHBs (OR: 3.1, 95% CI: 1.9, 4.8). Women had a higher NHB-NHW gap in BMI underestimation (OR: 4.6, 95% CI: 2.5, 8.2) than men (OR: 1.7, 95% CI: 0.8, 3.8; the interaction between sex and race $P < 0.01$) (42). Men with obesity had greater weight misperception, especially NHBs (OR: 3.0, 95% CI: 2.0, 4.5) compared with NHWs. In comparison, NHB (OR: 3.4, 95% CI: 1.4, 3.1) and MA women (OR: 1.9, 95% CI: 1.2, 3.2) with obesity had a higher weight misperception compared with NHW women (43).

For both men and women with obesity, those with less than a high school education had a higher weight misperception than those with a college education (Men: OR: 1.9, 95% CI: 1.4, 3.1; Women: OR: 5.5, 95% CI: 3.3, 9.3) (43). The people with overweight/obesity and having weight misperception were less likely to desire to lose weight and less likely to have tried to lose weight than those with a correct weight perception (44). This association was stronger among NHB males (OR: 5.8, 95% CI: 3.8, 8.8) and females (OR: 5.9, 95% CI: 3.6, 9.6) than MAs and NHWs (44). MAs and NHBs were less likely to try weight loss than others (45). When compared with NHWs, NHBs were significantly less likely to diet (OR: 0.78, 95% CI: 0.67, 0.90) or exercise to lose weight (OR: 0.83, 95% CI: 0.70, 0.99). Also compared with NHWs, MAs (OR: 0.71, 95% CI: 0.53, 0.95) and NHBs (OR: 0.71, 95% CI: 0.52, 0.95) were less likely to utilize professional help in attempting weight loss. The use of weight loss strategies was significantly different by race/ethnicity for females, but not for males (45).

The contributing roles of SES, weight-related behaviors, and neighborhood characteristics on racial/ethnic disparities in obesity

Overall, the studies we reviewed examined socioeconomic characteristics, health behaviors from early childhood to adulthood, built environments, and neighborhood context as contributing factors to racial/ethnic disparities in obesity, which include: education and income/poverty level among individual and neighborhood levels, personal health behaviors, including food choices, sleep duration, TV watching, exercise, SSB and fast-food intake, smoking, and

TABLE 2 Comparing ethnic-perspectives on body image, body dissatisfaction, and weight-control attempts in children and adults in the USA based on findings related to obesity of the 8 studies[1]

References	Research topics and study design	Key findings: racial/ethnic differences in body image, weight perception, body dissatisfaction, and weight-control attempts
Children		
Epperson et al., 2014 (40)	• Survey, AL, TX, CA • Differences in youth racial/ethnic groups with body size, image perceptions, and weight loss • 5th graders, M/F, NHB/H/NHW, $n = 3954$	Positive body perception was associated with fewer weight loss attempts in NHWs ($\beta = -0.51$, $P < 0.05$) and H ($\beta = -0.41$, $P < 0.05$) but not in NHBs; body size was positively associated with weight loss attempts in NHWs ($\beta = 0.46$, $P < 0.05$) and H ($\beta = 0.52$, $P < 0.05$), but not in NHBs (all SEs were not available)
Krauss et al., 2012 (38)	• NSY[2] • Examining racial/ethnic differences in weight misperceptions • 12–17 y, F, NHB/H/NHW, $n = 5035$	NHBs were 28.6% more likely to underperceive their weight status compared to H (15.9%) and NHWs (12.9%); NHWs were 73% more likely to perceive their OW correctly compared to Hs (62.5%) and NHBs (46.6%)
Mikolajczyk et al., 2012 (39)	• HBSC[2] • Examining the differences in perceptions in body satisfaction and body appearance related to poor health or weight problems • 11–17 y, M/F, NHB/H/NHW, $n = 14{,}818$	NHBs were more likely to think their weight about right when their reported BMI was >90th percentile than others (data were not shown). However, about half of NHB boys did not consider themselves good-looking anymore after getting old (60% at age 11 y vs. 30% at age 17 y)
Adults		
Marquez and Murillo, 2017 (45)	• NHANES[2] • Differences in weight loss strategies • 20–65 y, M/F, NHB/MA/NHW, $n = 9046$	For weight loss, NHBs were less likely to use diets than NHWs (OR: 0.78, 95% CI: 0.67, 0.90) or exercise for weight loss (OR: 0.83, 95% CI: 0.70, 0.99). MAs (OR: 0.71, 95% CI: 0.53, 0.95) and NHBs (OR: 0.71, 95% CI: 0.52, 0.95) were less likely to use professional help for weight loss than NHWs
Hendley et al., 2011 (42)	• Survey, AT • Examining cultural differences in perceived weight status compared to BMI calculation • 30–66 y, M/F, NHB/NHW, $n = 459$	NHBs underestimated their weight status compared with NHWs (OR: 3.1, 95% CI: 1.9, 4.8, after adjusting for SES and comorbidities); NHB vs. NHW women had the greater odds of underestimating weight (OR: 4.6, 95% CI: 2.5, 8.2) than NHB vs. NHW men (OR:1.7, 95% CI: 0.8, 3.8; interaction between gender and race $P < 0.01$)
Kronenfeld et al., 2010 (41)	• Online survey • Examining body image and body dissatisfaction (current-preferred silhouette) using 9 silhouettes • 25–45 y, F, NHB/NHA/NHW, $n = 3733$	NHBs *1*) had a smaller self-body perception [β (SE) = −0.26 (0.09), $P < 0.01$], *2*) preferred a larger body [higher preference of silhouettes 5–7 (data not shown), $P < 0.01$], and *3*) had a lower body dissatisfaction [β (SE) = −0.46 (0.08), $P < 0.01$] than NHWs after adjusting for BMI
Dorsey et al., 2009 (43)	• NHANES[2] • Examining racial/ethnic differences in weight misperception • ≥20 y, M/F, NHB/MA/NHW, $n = 15{,}954$	Weight status misperception among men with obesity was higher for *1*) NHBs (OR: 3.0, 95% CI: 2.0, 4.5) than NHWs, *2*) having <high school education (OR:1.9, 95% CI: 1.4, 3.1) than those with college education; weight status misperception among women with obesity was higher *1*) NHBs (OR: 3.4, 95% CI: 1.4, 3.1) than NHWs, *2*) MAs (OR: 1.9, 95% CI: 1.2, 3.2) than NHWs, *3*) having <high school education (OR: 5.5, 95% CI: 3.3, 9.3) than those with a college education
Dorsey et al., 2010 (44)	• NHANES[2] • Examining racial/ethnic differences in weight management behaviors and weight perception for OWB • ≥20 y, M/F, NHB/MA/NHW, $n = 11{,}319$	OWB group with correct weight perception was more likely to try to lose weight compared with those with weight misperceptions, and the magnitude of association was strongest among NHB males (OR: 5.8, 95% CI: 3.8, 8.8) and females (OR: 5.9, 95% CI: 3.6, 9.6) compared to other ethnic groups (NHW male: OR: 2.8, 95% CI: 2.2, 3.6; MA female: OR: 2.6, 95% CI: 1.8, 3.7)

[1]All studies had a cross-sectional study design, and their global score of study quality assessment was 8. Contents were ordered by age group and publication year.
[2]A nationally representative sample.
F, female; H, Hispanic; HBSC, Health Behavior in School-aged children; M, male; MA, Mexican American; NHA, non-Hispanic Asian; NHB, non-Hispanic black; NHW, non-Hispanic white; NSY, National Survey of Youth; OW, overweight; OWB, combined overweight and obesity; SES, socio-economic status.

neighborhood socioeconomic context and built environments, such as population density, poverty, education level, safety, the price of fast food, availability of grocery stores and supermarkets, street connectivity, physical activity outlets, and walkability. The higher obesity risk in NHBs and Hispanics compared with NHWs was significantly attenuated after adjusting for these factors. However, the degrees of changes were varied by study population and examined factors in most studies, and 46.9% of observations had a significant mediation effect (**Table 3**).

One study found that household SES had a higher association than health behaviors with racial/ethnic disparities (46). The combination of household composition, residence, household education, and poverty status explained the higher risk of obesity in NHB and Hispanic children compared with NHW children by 22–23%. Including individual health behaviors (e.g. amount of television viewing, recreational computer use, physical activity, and sport participation) in the model explained additional 5–7% of the higher obesity risk only (46). Also, in adults, individual education level and household income attenuated the higher obesity risk in minorities more than food choice: while food choice explained 2% of the higher risk in obesity of NHBs vs. NHWs, income and education did 38% (47).

In contrast, 3 studies suggested that early life health factors and childhood health behavior change could highly impact the gap between NHB-NHW and Hispanic-NHW in the risk of childhood obesity. After adjusting for maternal pregnancy characteristics, breastfeeding, infancy weight change, SSB and fast-food intake, sleep duration, and having a TV in the bedroom, the higher risk of overweight/obesity decreased by 33–66% between NHB-NHW children and 24–41% between Hispanic-NHW children. In contrast, SES only adjustment changed less, ∼14% and 18% of the risk of overweight/obesity (48, 49). Changes in exercise and TV watching time explained 32% and 14% of NHB-NHW and Other-NHW difference in subsequent obesity risk among children in a longitudinal study (50).

Besides individual/household characteristics, neighborhood contexts were also considered for racial/ethnic disparities in obesity. Minority children and adolescents' higher risk of obesity was decreased 19–27% after adjusting for the individual's poverty to income ratio and neighborhood SES level (51). Neighborhood economics, built environments, state obesity program, residence region, in addition to individual SES, and smoking habit explained ∼20% of higher obesity risk in minority adults compared with NHW adults (52). However, 1 study showed ethnic-specific changes after considering individual sociodemographic, smoking/alcohol consumption status, physical activity, diets, and residence region together in obesity disparities. The Hispanic-NHW gap and Other-NHW gap in obesity increased by 4–13%, but the NHB-NHW gap reduced by 2% (53). Sex-specific neighborhood influence was also shown in 2 studies. Among adolescents, the proportion of explained gap by neighborhood built environments and contextual factors was greater in boys than in girls (boys vs. girls: 28% vs. 13% in the NHB-NHW gap; 38% vs. 7% in the Hispanic-NHW gap) (54). Population density, walkability, and distance to parks dropped 2–5% of higher risk of obesity in minority men but increased 4–12% in minority women (55). Considering nativity in the analysis also increased the NHB-NHW gap in prepregnancy obesity risk (56).

Discussion

This study examined racial/ethnic disparities in obesity in the USA and comprehensively explored its related contributing factors to address the obesity epidemic. Obesity and severe obesity prevalence have been higher since 2007, after a short leveling-off between 2009 and 2012. The racial/ethnic disparities in severe obesity of women significantly decreased due to the dramatic drop in NHB women, but a steady increase in other racial/ethnic groups remained across the decade. However, boys experienced higher racial/ethnic disparities in both obesity and severe obesity than before due to the steep increase in MA group compared with no significant difference in other racial/ethnic groups during the study period, especially in severe obesity. Along with our previous review in 2007, the increasing obesity prevalence continued in some groups, and racial/ethnic disparities in obesity have not stopped during the last 13 y.

Considering sociocultural influence

Observing variations in an individual's perception and behaviors and surrounding environments are significant for understanding obesity disparities. First, we need to consider the mediating role of cultural differences and preferences in personal body image and weight underestimation. The patterns of body dissatisfaction and body perception, and their motivation for weight loss were varied by sex and race/ethnicity. NHBs are more likely to underestimate their weight status than Hispanics and NHWs, independent of age. This characteristic is especially apparent in females and those with less than a high school education compared with those with a college education (38, 43). Therefore, it is essential to promote the correct weight perception and healthy body image to encourage healthy weight control behaviors, especially for NHB females. Individuals view silhouettes differently based on their culture from childhood, and their perception influences health behaviors in later life (12). For example, body size and body perception were associated with weight loss attempts in NHW and Hispanic youth, but not in NHB youth (40). Hispanic youths were more likely to have negative body perception and attempt weight loss than NHB and NHW counterparts (40). The type of weight loss attempts varied considerably by race/ethnicity for females between dieting, exercising, and seeking professional help (45). These cultural differences and preferences in body image and weight underestimation can be targeted in school-based education during adolescence, which is the most effective strategy indicated in the literature (57, 58). Such programs also could incorporate the promotion of correct weight perception and healthy weight control behaviors across all ethnicities. NHBs have shown more weight loss attempts

TABLE 3 Published findings on the associations and contributing roles of socioeconomic status, health behaviors, and neighborhood characteristics on racial/ethnic disparities in obesity in the USA[1]

Reference	Study design	Contributing variables	Outcomes	Key results[2]
Children				
Rossen, 2014 (51)	• NHANES[3] • 2–18 y, $n = 17{,}100$	• Poverty to income ratio, neighborhood SES	• OB	• The NHB-NHW gap and MA-NHW gap reduced by 27% and 19%, respectively
Taveras et al., 2013 (48)	• Viva birth cohort[1] • 7 y, $n = 1116$	• Household SES[4] • Early childhood health factors[5]	• OWB	• The NHB-NHW gap and H-NHW gap reduced by 14% and 18%, respectively • The NHB-NHW gap and H-NHW gap reduced by 33% and 24%, respectively
Lee, 2012 (50)	• ECLS-K[1,3] • 5–11 y, $n = 11{,}400$	• Changes in exercise and TV watching time	• Longitudinal change in BMI percentile	• The NHB-NHW gap, H-NHW gap, and Other-NHW gap reduced by 32%, 1%, and 14%, respectively, but NHA-NHW gap increased by 1%
Singh et al., 2008 (46)	• NSCH[3] • 10–17 y, $n = 46{,}707$	• Household SES[6] • Household SES[6] + health behaviors[7]	• OB	• The NHB-NHW gap, H-NHW gap, and Other-NHW gap reduced by 22%, 23%, and 13%, respectively • The NHB-NHW gap, H-NHW gap, and Other-NHW gap reduced by 27%, 26%, and 20%, respectively
Isong et al. 2018 (49)	• ECLS-B[1,3] • 9 mo–5 y, $n = 10{,}700$ • Oaxaca-Blinder decomposition method	• Household SES, pregnancy health factors, early childhood behaviors[8]	• BMI *Z* score	• Explained 63% (M)/51% (F) in NHB-NHW gap, 36% (M)/41% (F) in H-NHW gap, 55% (M)/25% (F) in NHA-NHW gap, and 38% (M)/43% (F) in NHI-NHW gap
Powell et al., 2012 (54)	• NLSY[3] • 12–17 y, $n = 8984$ • Oaxaca-Blinder decomposition method	• Parental SES • Neighborhood contextual factors[9]	• Mean BMI	• Explained 18% (M)/8% (F) in NHB-NHW gap and 28% (M)/27% (F) in H-NHW gap • Explained 28% (M)/13% (F) in NHB-NHW gap and 38% (M)/7% (F) in H-NHW gap
Adults				
Koh et al., 2020 (52)	• US Census[3] • ≥18 y, $n = 211$ million • Inverse probability weighting decomposition method	• SES, smoking, neighborhood economics, built environments, state obesity program, region	• Mean BMI OB prevalence per 100 population	• Explained 19% in NHB-NHW gap • Explained 21% in NHB-NHW gap
Singh and DiBari, 2019 (56)	• National birth cohort[3] • Reproductive-age females, 18–49 y, $n = 10{,}431{,}092$	• Sociodemographic[10]	Prepregnancy • OB • OWB	• The NHB-NHW gap increased by 2% • The NHB-NHW gap increased by 3%
Shaikh et al., 2015 (53)	• NHIS[3] • ≥18 y, $n = 23{,}434$	• Sociodemographic, smoking/alcohol consumption status, physical activity, diets, region	• OB	• The NHB-NHW gap reduced by 2%, but H-NHW gap and Other-NHW gap increased by 4% and 13%, respectively
Wen and Kowaleski-Jones, 2012 (55)	• NHANES[3] • ≥20 y, $n = 9739$	• Population density & neighborhood built environments[11]	• OB	• M: The NHB-NHW gap, H-NHW gap, and Other-NHW gap increased by 8%, 4%, and 12%, respectively • F: The NHB-NHW gap, H-NHW gap, and Other-NHW gap reduced by 2%, 5%, and 3%, respectively

(*Continued*)

TABLE 3 (*Continued*)

Reference	Study design	Contributing variables	Outcomes	Key results[2]
Wang and Chen, 2011 (47)	• CSFII[3] • ≥20 y, $n = 4356$	• Food choice[12] • Household income and individual's education level	• OWB	• The NHB-NHW gap and H-NHW gap reduced by 2% and 1%, respectively • The NHB-NHW gap and H-NHW gap reduced by 38% and 3%, respectively

Contents were ordered by age group and publication year.

[1] Longitudinal studies were indicated and their global score of study quality assessment was 10. Others were cross-sectional studies, and their global score of study quality assessment was 8.

[2] Results were presented by percent change in the gap between minority-NHWs on obesity risk after adjusting for SES, behaviors, and neighborhood environments, or the proportion of explained gap between minority-NHWs by SES, behaviors, and neighborhood environments.

[3] A nationally representative sample.

[4] Maternal age, education, parity, and household income.

[5] Parental BMI, pregnancy characteristics, breastfeeding, infancy weight change, insufficient sleep, having a TV in the bedroom, sugar-sweetened beverage intake, and fast-food intake.

[6] Household composition, place of residence, language use, household education or poverty status, social capital, and perceived neighborhood safety.

[7] Amount of television viewing, recreational computer use, physical activity, and sports participation.

[8] Household SES, food insecurity, neighborhood safety, maternal weight and smoking status during pregnancy, breast feeding, solid food introduction, infancy weight gain, TV viewing, physical inactivity, SSB/fruit/vegetable consumption, family meals child care.

[9] Neighborhood food prices of fast food and food at home, fast food & full-service restaurant, grocery and convenience stores, and supermarkets with physical activity outlets, and socioeconomic contextual factors.

[10] Age, parity, marital status, nativity, education, and place/region of residence.

[11] Population density, street connectivity, percent residents walking to work, distance to parks.

[12] Food choice (consideration in buying foods) was defined by 6 considered factors when buying food, including food safety, nutrition, price, refreshment, convenience, and taste. The higher score indicated the more consideration in buying food. The model adjusted for sex, age, education, income, self-rated health, and other demographics.

CSFII, Continuing Survey of Food Intakes by Individuals; ECLS-B, Early Childhood Longitudinal Study-Birth Cohort; ECLS-K, Early Childhood Longitudinal Study-Kindergarten Cohort; F, female; H, Hispanic; M, male; MA, Mexican American; NHA, non-Hispanic Asian; NHB, non-Hispanic black; NHI, non-Hispanic American Indian; NHIS, National Health Interview Survey; NHW, non-Hispanic white; NLSY, National Longitudinal Survey of Youth; NSCH, National Survey of Children's Health; OB, obesity; OWB, combined overweight and obesity; SES, socio-economic status; SSB, sugar-sweetened beverage.

after having an accurate weight perception than NHWs and MAs (44), indicating a high likelihood of behavioral changes among NHBs from healthy body image education. Utilizing faith-based institutions as community settings for education and screening, campaigns, and social media could help racial/ethnic-specific social norm changes. Such interventions must be culturally sensitive (41) and include family and peers as partners in the education program (40, 43).

Modifiable health characteristics from early childhood

Second, obesity-related behaviors have been differently characterized by ethnic groups in the literature, even after adjusting for SES (46, 48). NHBs and Hispanics were more likely to consume SSBs. In contrast, Hispanics usually had low exercise levels, and NHBs had excessive screen time more common than others (9, 10). These ethnic-specific behavioral habits may differentiate the risk of obesity across racial/ethnic groups. Racial/ethnic disparities in obesity could originate from infancy characteristics, including maternal weight status, pregnancy characteristics, breastfeeding, the timing of solid food introduction, infancy weight gain, and sleep duration. One study reported a higher decrease in minority-NHWs obesity gap after considering SES, early childhood health factors and behaviors than SES only (48). Longitudinal data supported the causal relation between early childhood health factors and the subsequent minority-NHWs gap in overweight/obesity risk by more than one-third, a substantial contribution (48). Healthy characteristics and behaviors can be prepared and educated from early life with primary health care providers and teachers in childhood educational settings to reduce SSB and fast-food intake, promote sufficient sleep, integrate physical activity daily, and have healthy food and beverage options.

Living with neighborhood environments and contexts

The apparent role of neighborhood environments in obesity disparities were observed in studies. One study reported a significantly lower BMI level in safe neighborhoods compared with unsafe neighborhoods (47). The associations between low educational attainment and unsafe neighborhoods with higher BMI varied by racial/ethnic groups (14, 46, 54). Neighborhood economic factors and food environment explained more minority-NHWs BMI gap in males than females (54). Unsafe neighborhoods could be associated with higher BMI because of lack of exercise, increased stress, poor diet, and many other factors (59, 60). Thus, improving neighborhood safety would help to reduce disparities in obesity-related outcomes.

Further studies are needed to examine the moderating effects of neighborhood SES, food environment, and safety on the association between individual low SES status and a higher risk of obesity across race/ethnicity. The findings will help identify better intervention strategies in obesity between education programs and neighborhood enhancement efforts by specifying diverse needs in race/ethnicity and SES characteristics in the community. For example, although neighborhood safety improvement will lead to changes in all racial/ethnic communities, teaching at-home exercises, nutritious alternatives, and convenient and healthy cooking methods should be tailored to race/ethnicity and the specific needs of SES groups.

Racial/ethnic differences in physiology

Differences in adiposity levels, musculoskeletal system, and metabolic rate at the same BMI across racial/ethnic groups should be further studied to deal with obesity disparities. For example, NHB women had greater limb length and skeletal muscle than NHW women, accounting for their lower metabolic rate (61, 62). In contrast, the WHO expert committee recommended lowering the BMI cut-offs for obesity among Asian adults due to their higher body fat percentage (17, 25). Routine discussion of obesity risk between health care providers and NHA patients is a priority after considering the different levels of adiposity and metabolic risk as mediators of sex and racial/ethnic disparities in obesity. Applying additional biomarkers should be implemented to define the risk of obesity and not just rely on BMI alone. BMI is the most cost-effective way to analyze body mass but also has its limitations (29). Utilizing other biomarkers such as WC, skinfolds, visceral adipose tissue, and fat mass, shows higher accuracy in identifying cardiometabolic risk (25, 63–65). As WC is inexpensive and easy to measure, it should be used in conjunction with BMI to improve determination of the risk of obesity (28). These actions will improve the biased understanding of NHA and Hispanic populations and help achieve health equity as described in Healthy People 2030 (6).

Our study has several limitations. We reviewed diverse contributing factors with nonstandardized measures. As all behavior data in our study were self-reported, they are potentially biased by sex and race/ethnicity and have lower data quality than objectively recorded biomarkers. Causality could not be determined from the observational studies in our review. We did not address maternal health, weight status during pregnancy, the role of epigenetics, and microbiome due to the limited research on these topics. Nevertheless, to our knowledge, our study is the first to comprehensively examine age-sex-racial/ethnic specifically pooled prevalence of obesity in the USA using meta-analysis and contributing factors to racial/ethnic disparities in obesity, and provide useful insight into obesity intervention strategies considering ecological perspectives.

In conclusion, racial/ethnic disparities in obesity remained in some groups. Effective obesity prevention and management programs should consider racial/ethnic differences in biological, behavioral, and sociocultural characteristics.

Acknowledgments

The authors' responsibilities were as follows—YW and JM: conceived and designed the review; JM and HG: collected and analyzed the literature; JM: drafted the manuscript; HX and RB: edited the manuscript; and all authors: read and approved the final manuscript.

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