A Systematic Review of Literature on Representation of Racial and Ethnic Minority Groups in Clinical Nutrition Interventions

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KEYWORDS

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RUNNING TITLE

Underrepresentation of Racial and Ethnic Minorities in Nutrition Research

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CONFLICTS OF INTEREST

The authors have no conflicts to disclose.

ABSTRACT

There is a disproportionate increase in the incidence of diet-related cardiometabolic disorders in racial and ethnic minority groups. This systematic review examines the extent to which diet-induced changes in health outcomes have been discussed by race or ethnicity in randomized controlled trials recruiting both minority and non-Hispanic White groups. Databases i.e. PubMed, Cochrane library and Web of Science were searched up to November 2019. Studies

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that discussed effects of defined dietary interventions on health outcomes by racial or ethnic minority group vs. non-Hispanic Whites (n=29) were included in the review. Most studies were conducted in Black vs. White people testing effects of energy restriction, macronutrient modification, sodium reduction, or variations of the Dietary Approaches to Stop Hypertension (DASH) diet on cardiometabolic outcomes. There was limited focus on other minority groups. Evidence suggests greater blood pressure reduction for Black people compared to Whites particularly on DASH (or similar) diets. Overall, there was limited consideration for group-specific eating patterns and diet acceptability in most studies. Adequately powered studies are needed for accurate interpretation of race by diet effects. With emerging precision nutrition initiatives, it is imperative to ensure adequate representation of racial and ethnic subgroups for addressing nutrition-related health disparities.

INTRODUCTION

Approximately 40% of the US population comprises of non-White racial/ethnic groups [1]. The prevalence of major chronic diseases such as coronary heart disease, hypertension, obesity, and diabetes in racial and ethnic minorities is much higher than in Non-Hispanic White groups [2]. For example, Black people are 1.5 times more likely to have hypertension, American Indians are 1.5 times more likely to have coronary heart disease, and most racial and ethnic minority groups (except for Asians Americans) are 1.2-1.8 times more likely to have obesity, and 1.6– 2.9 times more likely to have diabetes than non-Hispanic White individuals. In addition, despite lower body weights, Asian Americans have a higher prevalence of diabetes.

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Racial and ethnic groups such as Black, Hispanic, Asian, and American Indian people or Pacific Islanders experience diet-related disparities. High saturated fat and salt intake, and low fruit, vegetable, and whole grain intake, resulting in suboptimal nutrient profiles, are especially evident in these racial and ethnic minority groups compared to Whites [3]. Diet-related disparities can arise at the biological, behavioral, environment (physical/built, sociocultural) and systems levels and contribute to chronic disease risk. Although, genetic predisposing factors may contribute to this increased prevalence of cardiometabolic diseases among these groups [4], these differences could result more often from interactions of genetic variants with environmental [5] and dietary factors, for example, carbohydrate and fiber [6] and dietary fat and monounsaturated fatty acids [7]. Poor diet quality can exacerbate the expression of the genes involved in metabolic dysfunctions such as insulin resistance [8]. Nutritional status is in part determined by food choices, which in turn are influenced by the environment. It is documented that ethnic and racial minority groups are systematically exposed to physical, socioeconomic, and political environments that hinder their ability to sustain healthful choices, including consistent consumption of nutritious food [9–15].

Findings on White groups cannot be assumed to be applicable to other groups and failing to recognize specific contextual factors that distinctively affect the nutritional status of ethnic and racial minorities can perpetuate disparities in their representation in research. Given the disproportionate increase in the incidence of diet-related cardiometabolic disorders in racial and ethnic minority groups, clinical nutrition research on these populations is critical. In fact, one of the stated research priorities of the American Society of Nutrition is to determine the variability in responses to diet and food components by population subgroups, including ethnic and racial minority groups [16].

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The purpose of this review is to report on clinical nutrition research on ethnic and/or racial minority groups in countries with predominantly non-Hispanic White populations. More specifically, the systematic review examines the extent to which diet-induced changes in health outcomes have been studied in randomized controlled trials with ethnic or racial groups vs. non-Hispanic Whites. In the text of this review, we use the same term to describe a specific ethnic or racial group as in the study being referenced.

METHODS

Search strategy

A comprehensive search strategy was developed in accordance with the Cochrane Handbook of systematic reviews [17]. This strategy employed a mixture of controlled vocabulary and natural language to reflect the focus of the analysis — to identify dietary studies that included racial and ethnic minority groups in clinical nutrition research trials. The searches were conducted until November 7, 2019. Complete search strategies are available in Supplementary Data (Supplemental Methods: Details of Search Methods). No restrictions were imposed on language, date of publication, or study design.

Study selection

The search was conducted across 3 databases (PubMed, Web of Science, and Cochrane Library) and the results were compiled in Zotero (version 5.0.87). Reference lists of related systematic reviews and meta-analyses were hand-searched to identify additional relevant articles. Three authors (JD, AJ, SO) reviewed the articles in a systematic manner for inclusion in the review. Any discrepancies were resolved via a vote for inclusion.

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In the first pass, the titles and the abstracts of articles were independently screened to identify potentially relevant articles based on the criteria. Articles were excluded if the studies 1) were duplicates, 2) were not clinical dietary interventions or the dietary intervention was not defined; 3) included children or pregnant women; 4) did not assess health outcomes; 5) did not have full texts; or 6) were published as conference abstracts. In the second pass, full-text of articles were screened and articles were excluded if the studies 1) recruited exclusively non-Hispanic White groups, 2) did not mention race or ethnicity, or 3) were conducted in countries where the predominant population is not non-Hispanic White. In the third and final pass, only studies that discussed health outcomes by racial or ethnic groups were included in the systematic review. Clinical dietary interventions included in the final pass are defined as studies that manipulate the dietary composition of participants' diets via a specific dietary prescription, foods, but not supplements or drugs. The study selection process is documented in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (Figure 1).

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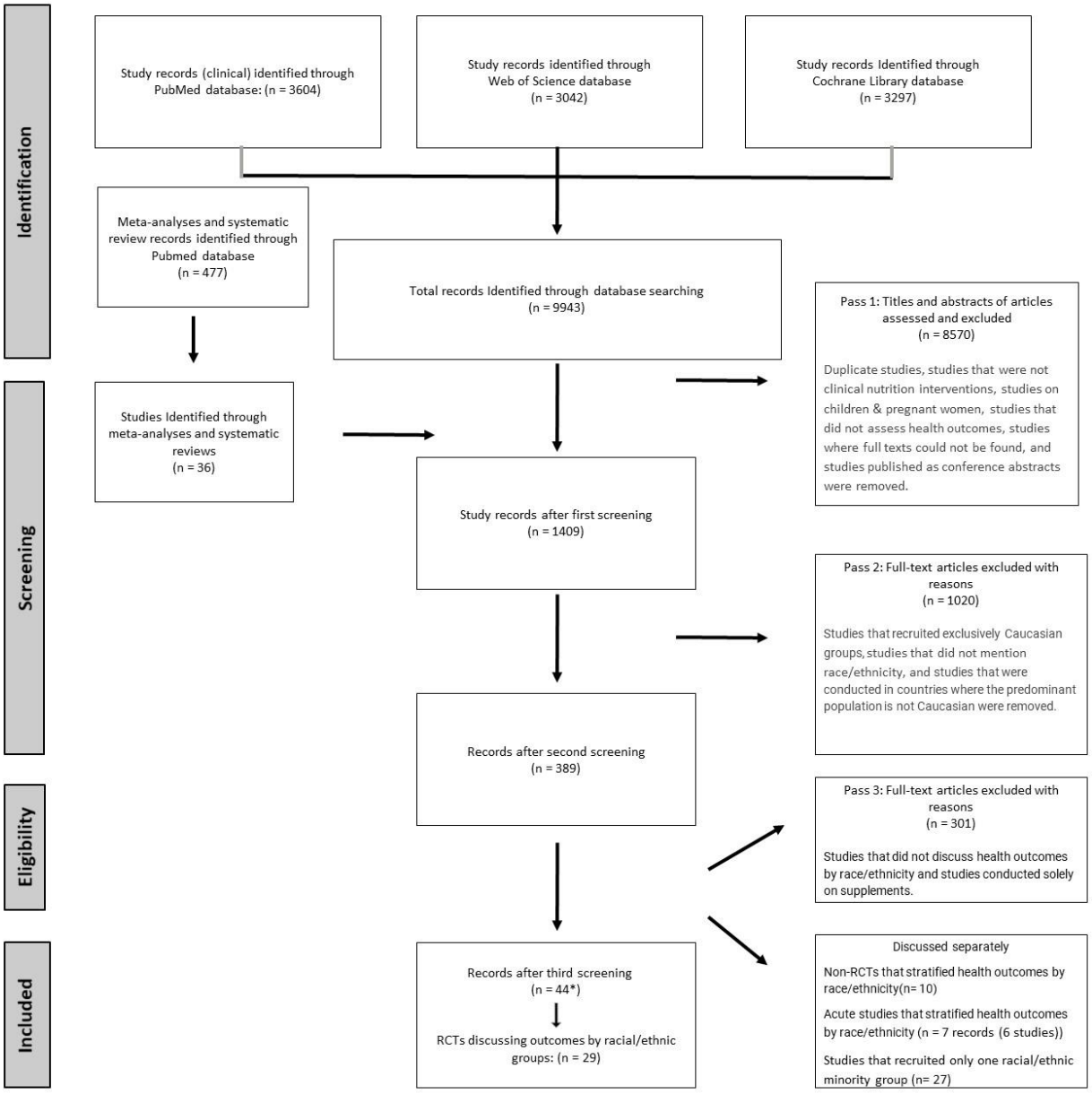

Figure 1: PRISMA flow diagram of included and excluded studies. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

*, Several studies were published as multiple articles. And, one article [34] discussed two studies.

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Data extraction

Data collection tables were developed by 1 author (JD) and variables were finalized in discussion with co-authors. Data extraction was completed by 2 authors (AJ, SO) and was reviewed for accuracy by JD. The quality of each study article was assessed using the Oxford Centre for Evidence-Based Medicine Levels of Evidence [18]. The risk of bias was evaluated with use of the Academy of Nutrition and Dietetics Quality Criteria Checklist (QCC) for Primary Research [19].

RESULTS

In total, 9943 studies were screened for inclusion, 9871 of which were excluded based on the established criteria (Figure 1). Twenty-nine randomized controlled interventions that discussed health outcomes by racial/ethnic group were included in the systematic review. Some studies had multiple publications discussing different outcomes and are grouped together in Table 1. Sixteen pertinent studies that accounted for race and/or ethnicity in their analyses were acute trials (n=6) i.e. not assessing changes in health outcomes over a period of time and non-RCTs (n=10), and hence did not fully align with established criteria for inclusion in the systematic review but are discussed separately. Twenty-seven studies that focused on a single racial/ethnic group are also discussed separately. The detailed inclusion and exclusion criteria are discussed in Figure 1.

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Table 1: Characteristics of included studies

Author	Design	Intervention duration	Total participants (minority participants)[1]	Racial/ethnic groups	Participant profile[2]	Dietary intervention	Main health outcome	Results by ethnicity/race X diet
Black and White people								
Branis et al. 2015 [54]	Crossover (2 groups)	1 wk	23 (12)	Black, non-Hispanic White	Women (age:25-45 years, BMI: 25-45 kg/m^2)	High fat vs. low-fat diet	Insulin sensitivity	Black (vs. White) ppl: lower insulin clearance on both diets
King et al. 2007 [67]	Crossover (2 groups)	3 wk	35 (16)	Black, White	Men and women (age: 18-49 years, BMI: 28 ± 1 kg/m^2)	High-fiber DASH diet vs. fiber-supplemented diet (both 30g/day)	C reactive protein (CRP)	Black (vs. White) ppl: similar DEC in CRP levels on both diets
Gerhard et al. 2000 [58]	Crossover (2 groups)	4 wk	22 (13)	Black, White	Pre-menopausal women (age: 18-45 years, mean BMI: 34 kg/m^2)	Low-fat, high-fiber diet vs. high-fat, low-fiber diet	Plasma lipids	Black (vs. White) ppl on high-fat, low-fiber diet: similar INC in plasma lipids
Wright et al. 2003 [59]	Crossover (2 groups)	7 days	199 (99)	Black, White	Women (age: 56 ± 8 years, BMI: 27 ± 4 kg/m^2)	High-salt diet vs. low-salt diet	BP	Black (vs. White) hypertensive ppl: greater mean arterial pressure and SBP INC with salt loading
Furtado et al. 2010 [61]	Crossover (total 4: 3 groups and baseline)	6 wk	162 (89)	Black, White	Men and women (age: 54 ± 11 (SD) years, BMI: 30 ± 6 (SD) kg/m^2)	Carbohydrate-rich vs. protein-rich vs. unsaturated fat-rich diets	Apo C-III-containing lipoproteins	Whites ppl on unsaturated fat and protein diets: DEC in apo C-III and triglyceride
Howard et al. 1995a [63] Howard et al. 1995b [65]	Crossover (total 5: 4 groups and baseline)	6 wk	63 (34)	Black, White	Hypercholesterolemic men and women (age: 46 ± 10 (SD) years, BMI: 26 ± 4 (SD) kg/m^2)	Baseline diet (37% total fat, 15% saturated) vs. 4 reduced-fat diets (30% fat, 10% saturated fat) of varying PUFA (3%, 6%, 10%, and 14%) and MUFA (17%, 14%, 10%, and 6%) content	Lipid profile	Black (vs. White) ppl: INC in triglycerides on reduced-fat diets [63]but similar DEC in total and LDL cholesterol on reduced-fat diets [63] No significant differences by race in response to varying PUFA/MUFA content of diets [65]
Erlinger et al. 2002 [30] Conlin et al. 2003 [26]	RCT (2 groups)	8 wk	55 (35)	Black, White	Hypertensive men and women (53 ± 9 (SD) years, BMI: 29 ± 5 (SD) kg/m^2)	DASH diet vs. control (+ Losartan)	Ambulatory BP (ABP), fibrinolysis markers	Black ppl on DASH diet (vs. control diet) + Losartan: greater DEC in ABP [26] No significant effect of race on markers of fibrinolysis [30]
Prather et al. 2011 [36]	RCT (2 groups for this analysis (originally 3 groups))	4 months	118 (43)	Black, White	Men and women with (SBP: 130–159; DBP: 85–99, age: age ≥35 years, BMI: 25–40 kg/m^2)	DASH diet vs. usual diet	BP	No significant diet x race effects Subgroup analyses: Black ppl on DASH diet (vs. control): improvement in SBP dipping postintervention White ppl on DASH diet (vs. control): no change in SBP dipping postintervention

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Goree et al. 2011 [49] Ellis et al. 2012 [48]	Randomized (2 groups)	8 wk	69 (33)	Black, White	Overweight men and women (premenopausal) (age: 21-50 years, BMI: 25-47 kg/m^2)	Standard diet (STD; 55% carbohydrate, 27% fat) vs. reduced-carbohydrate/higher-fat diet (RED-CHO; 43% carbohydrate, 39% fat)	Insulin sensitivity, β cell responsiveness, ghrelin	Black ppl: lower static β cell response to glucose with RED-CHO diet vs. STD diet [49] White ppl: similar static β cell response to glucose with RED-CHO diet and STD diet [49] No effects of diet x race on ghrelin [48] and insulin sensitivity [49]
Bales et al. 2017 [24]	RCT (2 groups)	6 months	78 (30)	Black, White, Other	Obese women (age: 45-78 years, BMI: 37.8 ± 5.9 kg/m^2)	Control weight-loss (C-WL; 0.8 g protein/kg body weight) vs. high-protein weight-loss (HP-WL; 1.2 g protein/kg body weight)	Weight	White (vs. Black) ppl: greater weight loss overall
Vollmer et al. 2001 [47] Bray et al. 2004 [46] Turban et al. 2013 [45] Derkach et al. 2017 [43]** Murtaugh et al. 2018 [44]**	RCT (2 groups) /Crossover (3 groups nested within the 2 main groups)	12-wk total (30 days each crossover period)	412 (234)	Black, White	Men and women with untreated elevated or hypertensive BP (mean age 48 ± 10 (SD) years, BMI: 29 ± 5 (SD) kg/m^2)	DASH diet vs. control (typical U.S.) diet (12 wk) Three sodium intake levels (30 days/level for each diet)	BP, urinary potassium excretion, metabolites (metabolomics analyses)	Black vs. White ppl: greater reductions in BP between (lower-higher) sodium intake on control diet [47] Black vs. White ppl on DASH diet: less 24-hour urinary potassium excretion at the highest sodium level [45] No significant effects of race and diet covariates on changes in metabolomic profiles in response to sodium intakes [43] Black vs. White ppl: Similar strong association of sodium with Systolic BP at lower levels of energy intake [44] Only Black ppl: Association of sodium and Diastolic BP varied with energy intake [44] Subgroup analyses: No effects of race on change in BP by diet [46]
Appel et al. 2001 [23]	RCT (2-4 groups)	Up to 3 years	681 (157)	Black, non-Black	Men and women (age: 66 ± 5 years, median BMI: 28 kg/m^2)	Reduced sodium diet vs. usual lifestyle (control)	Urinary sodium excretion	Black (vs. non-Black) ppl: Similar DEC in sodium excretion on reduced sodium diet (vs. control) Black ppl: significant relative hazard ratio of endpoints (reduced sodium vs. control) i.e. 0.56

Appel et al. 1997 [22] Svetkey et al. 1999 [39] Sacks et al. 1999 [37] Obarzanek et al. 2001 [35]** Chen et al. 2010 [25]** Hassoon et al. 2018 [31]** Tyson et al. 2018 [41]**	RCT (3 groups)	8 wk	459 (303) (Original study cite)	Black, White, Other	Men and women with SBP<160 mm Hg and DBP= 80-95 mm Hg (mean age: 44 years, mean BMI: 28 kg/m^2)	Control diet vs. fruits and vegetables rich diet vs. DASH combination diet	BP, lipids, blood calcitriol and PTH, 10-year CHD risk	No overall significant effects of diet x ethnicity on BP [22], calcitriol or PTH [31] Black (vs. White) ppl: Greater CHD risk reduction with DASH diet [25] Subgroup analyses: Black men on DASH diet (vs. control): greater reductions in calcitriol and PTH [31] Black (vs. White) ppl on DASH diet: Greater reduction in systolic BP [37,39] Black (vs. White) ppl on DASH diet (vs. control): Greater reductions in 24-hour SBP [41] Black (vs. non-Black) ppl on DASH diet (vs. control): Similar reductions in TC, LDL and HDL [35]
Djuric et al. 2002 [28]	RCT (4 groups)	12 wk	86 (32)	Black, White	Women (age: 18-50 years, BMI: 22–33 kg/m^2)	Low energy (25% reduction in intake) vs. low fat (15% fat) vs. low energy and low fat control	Weight, waist: hip ratio	No overall diet x race effects reported. Subgroup analyses: Black (vs. White) ppl on intervention diets: less weight loss but greater waist: hip ratio reduction
The Trials of Hypertension Prevention Collaborative Research Group, 1997 [40]	RCT (4 groups)	36 months	2382 (494)	Black, White, Other	Overweight men and women with SBP < 140 mmHg and DBP: 83-89 mm Hg (age: 30-54 years)	Intervention groups: weight loss, dietary sodium reduction and combined weight loss and dietary sodium reduction vs. control i.e. usual care	BP	Black (vs. White) ppl: similar greater reductions in BP on intervention groups (vs. control)
Hispanic and non-Hispanic White people								
Herron et al. 2002 [68]	Crossover (2 groups)	30 days	51 (22)	White, Hispanic	Women (age: 18-49 years, mean BMI: 29 kg/m^2)	High dietary cholesterol diet (1 egg) vs. placebo diet	Cholesterol	Hispanic (vs. White) ppl: similar INC in LDL-C and HDL-C on high dietary cholesterol diet
Asian and white people								
Garcia et al. 1991 [56]	Baseline period + Crossover (2 groups)	28 days	20 (6)	White, Asian (Chinese)	Women (age: 19-35 years, BMI: 18-25 kg/m^2)	Baseline self-selected diets vs. US74 diet (40% fat, PUFA/Sat fat =0.3) vs. MOD diet (30% fat, PUFA/Sat fat =1.0)	Cholesterol	Asian ppl: US74 diet (vs. MOD and self-selected diet): INC total and VLDL cholesterol White ppl: US74 diet (vs. MOD diet): INC total, LDL and VLDL cholesterol
Hsu et al. 2014 [32]	RCT (2 groups)	16 wk total (8 wk	50 (28)	Asian, White	Men and women (age: 25–55 years, BMI: 18.5–27	Traditional Asian diet (TAD, control) vs. typical Western diet (TWD, intervention)	Weight, insulin resistance	Asian (vs White) ppl: smaller weight gain, and greater INC in insulin AUC and HOMA-IR on TWD (vs. TAD)

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		control + 8 wk of either inteventi on or control)			kg/m2) at risk of developing type 2 diabetes			
Pima Indian and White people								
Swinburn et al. 1991 [55]	Crossover (2 groups)	14 days	24 (12)	Pima Indians, White*	Men and women (age: 18-37 years, BMI: 36 ± 13 (SD) kg/m^2)	Traditional Pima diet vs. high fat modern diet	Plasma lipids, glucose tolerance	Pima Indian (vs. White) ppl on high-fat modern diet: greater INC in plasma lipids, similar DEC in glucose tolerance
Multiple races or ethnicities								
Juraschek et al. 2016 [64]	Crossover (4 groups)	5 wk	163 (97)	Non-Hispanic White, non-Hispanic Black, Hispanic, Asian	Overweight and obese men and women (age: 53 ± 11 (SD) years, BMI: 32 ± 6 (SD) kg/m^2)	High GI (GI≥65) with high carbohydrate (58% kcal) vs, low GI (GI≤45) with low carbohydrate (40% kcal) vs. low GI with high carbohydrate vs. high GI with low carbohydrate	Glycated albumin (GA), fructosamine	Non-Hispanic Black and White ppl: similar reductions in GA and fructosamine with reduction in dietary carbohydrate
Samaha et al. 2003 [38]	RCT (2 groups)	6 months	132 (82)	Black, Hispanic, White	Men and women (mean age: 54 years, mean BMI: 43 kg/m^2)	Low carbohydrate vs. low fat diet	Weight	Black (vs. White) ppl: smaller weight loss
Perry et al. 2004 [53] Hung et al. 2008 [51]	Randomized (2 groups)	7 wk+7 wk	42 (28)	Black (14), Mexican American (MA, 14), White (14)	Women with methylenetetrahydrofolate reductase 677 CC genotype (age: 19-44 years, BMI: 19-32 kg/m^2)	Folate depletion: Baseline low-folate diet (135 micro g DFE/d) for 7 wk Folate repletion: 400 or 800 micro g DFE/d diet for next 7 wk	Blood folate, urinary folate, homocysteine, betaine, phosphatidylcholine	Black (vs. MA and White) ppl: lower blood folate and urinary folate excretions throughout folate depletion and 400 and/or 800 µg DFE/d repletion MA (vs. Black and White) ppl: lower plasma total homocysteine throughout folate depletion and 400 µg DFE/d repletion [53] MA and White ppl: plasma phosphatidylcholine tended to INC during 800 µg DFE/d repletion folate repletion [51] Significant but no clear wk x diet x race effect for plasma betaine [51]

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Hall et al. 2003 [69]	Original study RCT (2 groups).	6 months	2208 (979)	Non-Hispanic White, Black, Hispanic	Postmenopausal women (mean age: 60 years, mean BMI: 29 kg/m^2)	Low-fat intervention (total fat <20%) vs. control (no intervention)	Anthropometrics, glucose, insulin, BP, weight	White and Black ppl (low-fat vs. control): greater DEC in weight, waist and hips Hispanic ppl (low-fat vs. control): similar reductions in weight, waist and hips All ppl (low-fat vs. control): greater DEC in Systolic BP, BMI All ppl (low-fat vs. control): similar changes in glucose, insulin, and diastolic BP
Howard et al. 2010 [50]	Randomized (2 groups)	8.1 years	2730 (1401)	White, Black, Hispanic, American Indian/Alaska Native, Asian/Pacific Islander	Postmenopausal women (age: 50-79 years, BMI: <18.5 - >40 kg/m^2)	Low fat diet high in fruits, vegetables, and grains vs. usual diet control	Lipid profile	No effects of diet x race on triglyceride and HDL-C changes overall. Diabetic White (but not Black) ppl on low-fat diet (vs. control): greater INC in triglyceride
Maskarinec et al. 2017 [34] BEAN 1 trial Maskarinec et al. 2009 [42]**	RCT (2 groups)	2 years	220 (132)	White, Asian (Japanese, Filipino, Chinese), Native Hawaiian	Pre-menopausal women (mean age: 43 years, mean BMI: 26 kg/m^2)	High-soy diet i.e. 2 servings of soy foods daily (50 mg of isoflavones (aglycone equivalents) vs. low-soy diet i.e. <3 soy food servings per wk	Biomarkers of breast cancer risk, breast density, CRP, IL-6, adiponectin leptin	Asian ppl: DEC in IGF-1 on low-soy diet and INC on high-soy diet [34] Non-Asian ppl: INC in IGF-1 on low-soy diet and high-soy diet [34] No effects of diet x ethnicity (Asian vs. non-Asian) for other breast cancer biomarkers, breast density, IL-6, CRP, adiponectin and leptin [34] Subgroup analyses: Asian (vs. White) ppl: INC in leptin on low-soy diet [42]
Maskarinec et al. 2011 [66] Maskarinec et al. 2017 [34] BEAN 2 trial	Crossover (2 groups)	6 months	96 (48)	White, Asian (Japanese, Filipino, Chinese, Korean), Others (Native Hawaiian/Pacific Islander, Black, American Indian and other)	Pre-menopausal women (age: 39 ± 6 years, BMI: 26 ± 6 kg/m^2)	High-soy diet i.e. 2 servings of soy foods daily vs. low-soy diet i.e. <3 soy food servings per wk	Nipple aspirate fluid (NAF)	Asian (vs. White) ppl [66] and Asian (vs. non-Asian) ppl [34]: Similar effects (i.e. no change) on NAF volume in response to high-soy diet.

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Dodson et al. 1983 [20]	RCT (2 groups)	1 month	53 (34)	White, West Indian, Asian	Diabetic men and women with mild hypertension (mean age: 54 years)	High fiber, low fat and low sodium dietary regime vs. control diet	BP, urinary sodium excretion	White and West Indian ppl: similar DEC in DBP and urinary sodium excretion on intervention diet. Asian ppl: no changes on intervention diet.
Miketinas et al. 2019 [52]	Randomized (4 groups)	6 months	345 (44)	White, Black, Asian, Hispanic	Overweight and obese Men and women (age: 53 ± 9 (SD) years, BMI: 33 ± 4 (SD) kg/m^2)	Low fat, average-protein (20% fat, 15% protein) vs. low-fat, high-protein (20% fat, 25% protein) vs. high-fat, average-protein (40% fat, 15% protein) vs. high-fat, high-protein (40% fat, 25% protein)	Weight	Training model predicted a greater weight loss for White vs. non-White ppl MUFA intake was positively associated with weight loss for White (but not non-White) ppl No diet type x race effects reported
Wolever et al. 2011 [21]	RCT (5 groups)	4 wk	366 (70)	White, Non-White	Men and women with LDL-C ≥ 3.0 and ≤ 5.0 mmol/L (age: 35-70 years, BMI: 18.5 - 40 kg/m^2)	Wheat bran cereal (control) vs. oat cereal with 3 g high-molecular weight (MW) or 4 g Medium-MW or 3 g Medium-MW or 4 g Low-MW oat β-glucan	LDL-C	White and non-White ppl on oat β-glucan: similar reductions in LDL-C

[1]In case of multiple publications from the same study, the total number of participants from the main or first publication are listed.

[2]Age and BMI ranges presented. If range was not given, then either mean ± SD presented, or overall mean was calculated from individual group means

* One Iranian person not included in analysis

** Subset of original study participants

DEC: decrease, INC: increase; ppl: people

African American was changed to Black, and Caucasian and European was changed to White for consistency purposes.

Multiple publications from one study are grouped together

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Study design and duration

Twenty-seven studies were conducted in the US, 1 in the United Kingdom (UK) [20] and 1 study was a multi-center trial conducted in Australia, Canada and the UK [21].

Included studies varied in design, duration, and dietary intervention tested (Table 1). Thirteen studies [21–42] were randomized, controlled interventional trials with a parallel design (2-5 arms), of which the longest trial had a duration of 3 years and the shortest trials had a duration of 4 weeks. One study i.e. the Dietary Approaches to Stop Hypertension (DASH)–Sodium Feeding study was a 12-wk randomized, controlled interventional trial with a 2-arm parallel design and 30-day crossover diets nested within the 2 parallel groups [43–47]. Four studies were randomized trials with 2 to 4 dietary interventions (but no clear control group) in a parallel design [48–53]. Eleven studies [34,54–67] followed a crossover design in which participants were exposed to 2-5 dietary interventions, with interventions lasting between 1 week and 6 months.

Effects of dietary intervention on health outcomes by race or ethnicity

Most interventions were designed to modify the macronutrient composition of the diets and health outcomes largely included anthropometric markers (6 studies), blood pressure (BP, 8 studies), markers of glucose metabolism (6 studies), and lipids (10 studies) (Table 1). Study stratification by health outcomes is depicted in Figure 2.

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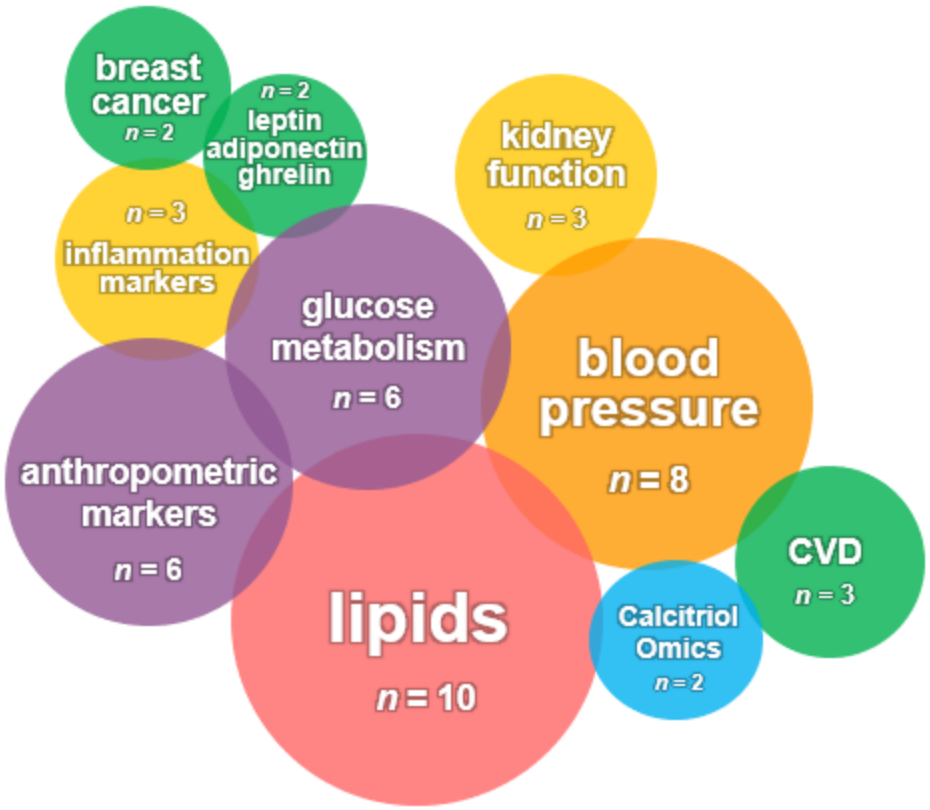

Figure 2: Health outcomes of dietary interventions studied in ethnic and racial groups. Lipids were outcomes in 10 studies, including total lipids, cholesterol, LDL cholesterol, HDL cholesterol, triglycerides, APO-CIII lipoproteins; blood pressure was an outcome in 8 studies; markers of glucose metabolism were outcomes in 6 studies, including blood glucose, glucose tolerance, insulin, insulin sensitivity, insulin resistance, glycated albumin, fructosamine, beta-cell responsiveness; anthropometric markers were outcomes in 6 studies, including, body weight, waist-to-hip ratio; inflammation markers were the outcomes in 3 studies; markers of kidney function were outcomes in 3 studies; leptin, adiponectin, or ghrelin were outcomes in 2 studies; markers of cardiovascular disease were outcomes in 3 studies; markers of breast cancer were main outcomes in 2 studies; markers of calcium metabolism, or metabolomics profiles were outcomes in 2 studies.

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Dietary interventions in Black or African American people (vs. Whites) largely examined effects of the DASH diet, or effects of modifying the salt or fat content of the diets on anthropometrics, lipid profiles, insulin sensitivity, and BP (Table 1). Notable results include hypertensive African Americans' having greater mean arterial pressure and systolic BP (SBP) increase with salt loading than Whites [59]. A few studies reported a smaller weight loss in Black people compared to White people on energy-restricted diets [24,28,38]. Analyses from two major studies i.e. the DASH diet study comparing dietary patterns, and the DASH-sodium study that compared effects of different levels of dietary sodium, in conjunction with the DASH diet reported differential effects of the dietary interventions between Black and White groups. For example, subgroup analyses from the DASH study reveal greater reduction in SBP [37,39] 24-hour SBP [41], calcitriol (men only) [31], TC, LDL and HDL [35], and CHD risk [25] on the DASH diet in Black people compared to Whites. In the DASH-sodium study, the reductions in BP between the lower and higher sodium levels on the control diet were greater in Black people versus Whites [47]. The 24-hour urinary potassium excretion at the highest sodium level on the DASH diet was lower for Black vs. White people [45].

Studies recruiting Asians, Hispanics or Pima Indians examined the differential effects of race or ethnicity largely on anthropometrics, glucoregulatory and lipid profiles. Asian people had increased total and VLDL while Caucasians had increased total, LDL and VLDL cholesterol on a higher-fat (lower PUFA) diet compared to lower-fat (higher-PUFA) [56]. Moreover, Asian people had smaller weight gain but greater increase in HOMA-IR than Caucasians when transitioning from a traditional Asian diet to a typical Western diet [32]. In one study, Hispanic and White people had similar increases in LDL and HDL on a high dietary cholesterol diet [68]. In the

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Women's Health Trial: Feasibility Study in Minority Populations, Black and White individuals but not Hispanics demonstrated a greater decrease in weight, and waist and hip circumference with a low-fat diet compared to the control [69]. A study on Pima Indians found that they had a greater increase in plasma lipids compared to Caucasians in response to a high-fat diet but both groups had better glucose-related metabolic indicators when on a traditional Pima diet compared to a high-fat diet [55].

A few studies examined responses to dietary interventions in multiple ethnic or racial groups. For example: a high fiber, low fat and low sodium diet resulted in similar decreases in diastolic BP and urinary sodium excretion in West Indian and White individuals, but no changes were observed for these outcomes in Asians [20]. Another study which grouped all non-Caucasian people together observed similar reductions in LDL with oat cereal with beta-glucan consumption in both Caucasian and non-Caucasian people [21].

Risk of bias and quality of assessment of studies included in systematic review

Characteristics of the included studies are summarized in Table 2. According to the Oxford Centre for Evidence-Based level of evidence, 39 study articles were classified as 1b i.e. high-quality individual RCTs and 6 were classified as 2b i.e. RCTs with less than 80% completion or follow-up. According to the Academy of Nutrition and Dietetics Quality Criteria Checklist for Primary Research risk of bias assessment, 31 articles were rated positive, indicating that they had adequately addressed issues of bias, generalizability, and data collection and analysis. The remaining 14 were found to be neutral, meaning that they were neither exceptionally weak nor exceptionally strong. It should be noted that several of these studies did not report or include diet

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by race interaction effects in the statistical model and instead present subgroup analyses for race or diet groups. Two studies adjusted for race or ethnicity in the statistical model but failed to adequately explain how the dietary intervention effects were stratified by race. Only 19 articles report conducting diet by race interaction analyses (Table 2).

Table 2: Risk of bias analysis of included studies

Study	Selection of participants free from bias	Study with > 80% follow-up	Standard/valid/ reliable data collection procedures	QCC Rating[1]	Evidence Grade [2]	Statistical analyses appropriate for diet x race effect interpretation[3]
Randomized studies						
Maskarinec et al. 2017 [34], BEAN 1 trial	Yes	Yes	Yes	+	1b	Yes
Maskarinec et al. 2009 [42]	Yes	Yes	Yes	+	1b	No
Appel et al. 2001 [23]	Yes	Yes	Yes	+	1b	No
Howard et al. 2010 [50]	Yes	Unknown	Yes	+	2b	Yes
Ellis AC 2012 [48]	Yes	Yes	Yes	Ø	1b	Yes
Goree et al. 2011 [49]	Yes	Yes	Yes	Ø	1b	No
Perry et al. 2004 [53]	Yes	Yes	Yes	+	1b	No
Hung et al. 2008 [51]	Yes	Yes	Yes	+	1b	Yes
Miketinas et al. 2019 [52]	Yes	Unknown	Yes	+	2b	No
Hsu et al. 2014 [32]	Yes	Yes	Yes	Ø	1b	No
Bales et al. 2017 [24]	Yes	No	Yes	Ø	2b	No
Erlinger et al. 2002 [30]	Yes	Yes	Yes	+	1b	No
Conlin et al. 2003 [26]	Yes	Yes	Yes	+	1b	No
Prather et al. 2011 [36]	Yes	Yes	Yes	+	1b	No
Dodson et al. 1983 [20]	Yes	Yes	Yes	Ø	1b	No
Hall et al. 2003 [69]	Yes	Yes	Yes	+	1b	No
Samaha et al. 2003 [38]	Yes	No	Yes	Ø	2b	No

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Vollmer et al. 2001 [47]	Yes	Yes	Yes	Ø	1b	Yes
Bray et al. 2004 [46]	Yes	Yes	Yes	Ø	1b	No
Turban et al. 2013 [45]	Yes	Yes	Yes	Ø	1b	Yes
Derkach et al. 2017 [43]	Yes	Yes	Yes	Ø	1b	Yes
Murtaugh et al. 2018 [44]	Yes	Yes	Yes	Ø	1b	Yes
Appel et al. 1997 [22]	Yes	Yes	Yes	+	1b	Yes
Hassoon et al. 2018 [31]	Yes	No	Yes	Ø	2b	Yes
Chen et al. 2010 [25]	Yes	Yes	Yes	+	1b	Yes
Svetkey et al. 1999	Yes	Yes	Yes	+	1b	No
Sacks et al. 1999	Yes	Yes	Yes	+	1b	No
Tyson et al. 2018 [41]	Yes	No	Yes	+	2b	Yes
Obarzanek et al. 2001 [35]	Yes	Yes	Yes	+	1b	Yes
The Trials of Hypertension Prevention Collaborative Research Group, 1997 [40]	Yes	Yes	Yes	+	1b	No
Djuric et al. 2002 [28]	Yes	Yes	Yes	+	1b	No
Wolever et al. 2011 [21]	Yes	Yes	Yes	+	1b	Yes
Crossover studies						
Branis et al. 2015 [54]	Yes	Yes	Yes	+	1b	Yes
Swinburn et al. 1991 [55]	Yes	Yes	Yes	Ø	1b	No
King et al. 2007 [67]	Yes	Yes	Yes	+	1b	No
Gerhard et al. 2000 [58]	Yes	Yes	Yes	+	1b	Yes
Garcia et al. 1991 [56]	No	Yes	Yes	Ø	1b	No
Herron et al. 2002 [68]	Yes	Yes	Yes	+	1b	Yes
Wright et al. 2003 [59]	Yes	Yes	Yes	+	1b	No
Furtado et al. 2010 [61]	Yes	Yes	Yes	+	1b	No
Howard et al. 1995a [63]	Yes	Yes	Yes	+	1b	No
Howard et al. 1995b [65]	Yes	Yes	Yes	+	1b	Yes

Maskarinec et al. 2011 [66]	Yes	Yes	Yes	+	1b	No
Maskarinec et al. 2017 [34], BEAN 2 trial	Yes	Yes	Yes	+	1b	Yes
Juraschek et al. 2016 [64]	Yes	Yes	Yes	+	1b	No

[1]QCC Rating [19]: +, Report has clearly addressed issues of inclusion/exclusion, bias, generalizability, and data collection and analysis; ∅, Report is neither exceptionally strong nor exceptionally weak.

[2]Oxford Centre for Evidence-Based Medicine Levels of Evidence [18].

[3]The statistical analyses rating is independent of and not accounted for in the QCC rating.

Other pertinent studies not included in systematic review

Acute studies

Six studies that accounted for race or ethnicity in their analyses were acute trials. Four studies assessed the glycemic responses to specific foods (including drinks) [70–73], one examined the effects of a high-fat vs. low-fat meal on cardiovascular outcomes [74] and one examined the effects of a high-glycemic vs. low-glycemic load meal on appetitive hormones [75,76]. Although, collectively, these studies do not demonstrate an appreciable difference in the acute responses to foods or meals by ethnicity or race, Woelver et al. [71] report potential differences in the glycemic index of starchy foods by Caucasian vs. non-Caucasian race but no mechanisms were discussed.

Studies with only one diet group or non-RCTs

Ten studies that accounted for race and/or ethnicity in their analyses either examined the pre-post effects of a dietary intervention such as low-fat, high-fiber, fruits, and vegetables diet [77], very-low calorie diet [78,79], high-fat high-calorie diet [80], or alternate-day fasting [81]; or were a post-diet analysis of an individualized diet [82], crossover studies of sodium dietary restriction (one dietary intervention) with sodium or placebo supplementation [83,84], or studies examining one dietary

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intervention with different physical activity conditioning [85,86]. Notably, one of those studies demonstrated greater skeletal muscle mass loss during diet-induced weight loss in European American in comparison to African American women who preserved muscle mass [85]. Another study found different metabolic adaptations for South Asian men compared to European men during energy restriction, i.e., improved glucose disposal rate and decreased shift from glucose to lipid oxidation in South Asians [79].

Studies with only one ethnic or racial minority group

Twenty-seven studies focused on only one ethnic/racial group. Eleven of such studies included only Black people, 5 studies included Hispanics or people of Mexican origin, 10 studies were on people of Asian origin, and 1 was on Native American people.

Dietary interventions for Black people assessed effects of beetroot juice [87,88], the DASH diet [89,90], meal plan emphasizing healthy food choices [91], sodium reduction [92,93], wheat bran [94,95], tomato product [96], or dairy [97] on diverse outcomes. Beetroot juice acutely increased blood nitric oxide concentrations [87,88] and decreased BP [88] at rest at different levels of exercise in healthy African American women. An 8-week DASH-dinner intervention reduced BP in low-income hypertensive African American adults [89]. Sodium reduction interventions reduced BP [93] and identified metabolites associated with sodium reduction [92] in Black hypertensive people. Moreover, a high dairy diet for 24 weeks decreased adiposity, insulin and BP compared to a low dairy diet in African Americans with obesity, without weight loss [97].

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Dietary interventions for Hispanic people comprised of traditional Mexican diet [98], high-fiber, moderate glycemic index Mexican diet [99], low-fat traditional diet in Caribbean Hispanics [100], folate and choline-enriched diets [101], oat bran cereal with beta-glucan [102]. A traditional Mexican diet for 24 days improved insulin sensitivity in healthy Mexican women compared to a common US diet [98]. In another study [100], Caribbean Hispanics who were major allele carriers of the LIPC locus had lower HDL cholesterol following a 4-wk traditional diet compared to a Western diet.

Dietary interventions for South Asian people comprised of moderate or high PUFA-diets [103,104], fried karela fruit [105], and moderately low-carbohydrate energy-restricted diet [106]. The latter decreased insulin resistance, and reduced cardiovascular disease risk factors in overweight, insulin resistant Indian women [106].

Dietary studies for East Asian people comprised of cereal based diets [107–109], acute effects of kiwifruit preloads [107], American heart association step 1 and 2 diets [110,111], and intermittent energy restriction combined with Mediterranean diet (IER+MED) [112]. Notable results include improvement in metabolic risk factors when substituting brown rice for white rice for 3 months in pre-diabetic Chinese American population [108]. Moreover, consuming an IER+MED diet for 12 weeks improved indices of liver function more than the DASH diet among East Asians in Hawaii.

Lastly, a flaxseed intervention in hypercholesterolemic Native American women resulted in reduced total and LDL cholesterol [113].

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DISCUSSION

Summary of evidence

Our search revealed that only 3% of peer-reviewed articles on clinical nutrition interventions (records after third screening: records after first screening) had study designs appropriate for discussing health outcomes by race or ethnicity. This stands in striking contrast to the disproportionate burden of diet-related conditions experienced by ethnic and racial minority groups. Most studies were conducted in Black vs. White individuals testing dietary interventions on energy restriction, macronutrient modification, variations of the DASH diet, or sodium reduction protocols. There was limited focus on other ethnic or racial groups.

Evidence from RCTs suggest a smaller diet-induced weight loss for Black people compared to White people [24,28,38]. These findings are supported across literature on weight-loss interventions particularly for Black women [114,115]. Possible explanations include higher baseline weight [28] and fat-free mass [116] and preservation of skeletal muscle mass during weight loss [85]. Despite smaller weight-loss, greater improvements in waist-hip ratio [28] were observed. Interestingly, a decrease in adiposity with dietary interventions is also seen independent of weight loss in Black individuals [97]. Another possible explanation is limited consideration for group-specific eating patterns, cultural preferences, and lifestyle factors in the design of the diet treatment to achieve comparable adherence [117–120]. Many of the studies reviewed did not report whether the diet treatment was tailored for acceptability by all the groups studied.

The high prevalence of high blood pressure among Black individuals has led to the development of several dietary interventions, the most popular being the DASH diet and its reduced sodium version). The DASH approach is a diet rich in fruits, vegetables, and low-fat dairy products with reduced saturated and total fat. Overall evidence supports greater reductions in sodium intake and BP with the DASH diet in Black vs. White people. Several explanations

have been proposed for these differences, such as Black people having increased salt sensitivity, greater body mass, and lower baseline dietary potassium intake. Nonetheless, more research is needed to further characterize the factors contributing to these differences and their potential relevance to other diet-related outcomes and interventions [121].

Because human nutrition is complex and dynamic, factors beyond intake need to be considered when designing research interventions. Thus, future studies need to explore the effectiveness of culturally sensitive interventions, controlling for social, economic, and environmental factors to investigate racial and ethnic disparities in nutritional outcomes. Accounting for the socioecological context that inform intake allows for robust interpretation of findings and can provide key information to ascertain adoption and sustainability in real life circumstances.

Strengths and limitations

This review is unique in that it profiles the representation of racial and ethnic minority groups in clinical nutrition interventions conducted in regions where non-Hispanic Whites are the majority population group. A strength of the systematic review is the large volume of literature considered in the initial search and the diversity of outcomes screened. However, the heterogeneity of dietary interventions and outcomes in the included studies limited the ability to make direct comparisons among studies. We attempted to minimize this limitation by excluding studies that deployed lifestyle interventions where the dietary intervention was not explicitly defined.

Most studies examined the differential effects of dietary interventions by race or ethnicity in subgroup analyses that ignored diet by race interaction effects. There is a need for adequately powered studies for accurate interpretation of race by diet effects. Differences in outcomes by

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race and ethnicity cannot be suitably studied with insufficient sample sizes for population subgroups. Factors that help explain variability in responses and those that can offer mechanistic insight, such as omics techniques, and socioecological context, should be included and adequately powered [115]. Lastly, an added strength of this overall review is that studies of lower evidence quality—for example uncontrolled interventions and acute studies and studies focusing on one ethnic/racial group—were not dismissed but reported separately to provide a more comprehensive review of the available evidence.

Conclusions

A scant proportion of the clinical nutrition research conducted with ethnic and racial groups is robust enough to confidently identify interventions to reduce health disparities and explore their subsequent mechanisms. Most of the few studies with quality designs have been conducted with Black and African American groups to study dietary interventions to improve cardiovascular and weight-related outcomes. With emerging precision nutrition initiatives that aim to optimize metabolic responses in individuals or population subgroups through tailored dietary approaches, it is imperative to ensure adequate representation of racial and ethnic subgroups for understanding and eliminating nutrition-related health disparities. In addition, moving beyond the traditional attribution to genetics, key questions remain on the socioecological mechanisms and contextual factors that contribute to explain intervention success or failure. Characterizing such factors is paramount to establishing replicability in research and feasibility in practice.

The gap in clinical nutrition research with ethnic and racial minorities is large, thus, the possibilities are vast. The parallel nutrition disparities affecting these groups [122] underscores the urgency of closing such gap. An intentional and joint commitment from all sectors involved in

the clinical nutrition research enterprise—from conception and funding to implementation and dissemination—is required to cogently achieve sufficient representation of ethnic and racial groups in clinical nutrition research.

AUTHOR CONTRIBUTIONS

The authors' responsibilities were as follows—JD designed the study; JD, AJ, SO extracted data; and JD, AJ, KDR wrote the paper. All authors read and approved the final manuscript and take responsibility for the final content.

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