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Review

Electronic health (eHealth) interventions for weight management among racial/ethnic minority adults: a systematic review

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Summary

Electronic health (eHealth) interventions have demonstrated efficacy for weight management. However, little is known about their efficacy among racial/ethnic minority populations, in whom there is a disproportionate prevalence of obesity. This systematic review evaluated the efficacy of eHealth weight management interventions among overweight and obese racial/ethnic minority adults. We required that trial samples be comprised of at least 50% racial/ethnic minorities or report outcomes by race/ethnicity. We searched five electronic databases for trials conducted through June 2012. Six papers met our eligibility criteria. These studies provide suggestive evidence that eHealth interventions can produce low magnitude, short-term weight loss among racial/ethnic minorities. Trials were methodologically sound, with high retention and participant engagement. There was no evidence detailing the efficacy of mobile health approaches, although this area is promising given high utilization rates of mobile devices among racial/ethnic minorities. More evidence, particularly from longer-term trials, is necessary to demonstrate that eHealth intervention approaches can produce clinically meaningful (≥5% of initial body weight) weight loss among racial/ethnic minority populations.

Keywords: eHealth, intervention, obesity, race/ethnicity.

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Introduction

Recently, a large and growing body of evidence has demonstrated the efficacy of electronic health (eHealth) interventions for weight management (1). Although intervention designs vary considerably, one systematic review (1) reported that the most successful eHealth interventions are typically structured, offer interpersonal support, utilize tailored components and promote high levels of participant engagement. Despite the apparent promise of eHealth weight management interventions, little is known about their efficacy in racial/ethnic minority populations.

Few trials in the extant eHealth literature include racially and ethnically diverse participants, or report outcomes by race/ethnicity (1). This is a major limitation because obesity remains disproportionately prevalent among several US racial/ethnic minority groups, notably non-Hispanic black and Hispanic populations (2). These groups demonstrate high rates of weight gain in adulthood and extreme obesity, which contribute to their excess risk of obesity-associated chronic disease (3). However, with some exceptions (4,5), relatively few evidence-based interventions have produced clinically meaningful weight loss outcomes (≥5% of initial body weight) among racial/ethnic minority populations.

Thus, identifying effective treatment options for these groups is a high priority (6).

Efforts to test eHealth approaches in racial/ethnic minority populations have been complicated by historical disparities in computer ownership and Internet access. Although gaps in home broadband access and desktop computer ownership remain, the emergence of myriad mobile computing and Internet connectivity options has drastically minimized the 'digital divide' (7,8). For example, racial/ethnic minorities are more likely than whites to own laptop computers and mobile phones (7). Blacks and Hispanics are similarly more likely than whites to use their mobile phones for Internet access and advanced data functions (e.g. sending and receiving email, video, or pictures; downloading applications and sending text messages) (7,8). Indeed, in some studies, disparities in Internet access disappear when mobile access is considered (8).

The primary aim of this systematic review is to evaluate the efficacy of eHealth weight management interventions among overweight and obese racial/ethnic minority adults. We identified eHealth interventions using Bennett and Glasgow's definition (9): interventions delivered via computer, mobile phone or similar media; through platforms such as Internet website/web applications; mobile or social network applications; email or SMS text messaging.

Methods

The conduct and reporting of this systematic review followed the guidelines recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (10).

Eligibility criteria

Selection of eligibility criteria was structured using the 'PICOS' components: participants, intervention, control, outcome measures and study design (10).

Participant characteristics

We included trials with participants ≥18 years old, who were overweight or obese (body mass index ≥ 25 kg m^{-2}) at baseline or who were overweight at the start of a weight maintenance trial. Trial samples were comprised of at least 50% racial/ethnic minorities or the studies reported outcomes by race/ethnicity. No health status restrictions were imposed.

Intervention types

We included adjunctive or sole interventions for weight loss, weight gain prevention or weight loss maintenance. Eligible interventions used an eHealth modality and required participant interaction with interactive, electronic components that were delivered via computer, web, text, mobile phone, applications, email or related technologies.

Outcome measure

The outcome measure was weight change over time, with weight assessed at baseline and at least once following exposure to intervention.

Study design

We included experimental trials designed to investigate the efficacy of eHealth interventions. Studies were excluded if they were not based in the United States or were published in a language other than English. Also excluded were interventions that included bariatric surgery or obesity medications, trials that included supervised exercise or feeding studies designed to investigate the impact of weight loss on another clinical outcome.

Search processes

We identified studies by searching a number of electronic databases, reviewing systematic reviews on related topics and examining the reference citations of included papers. We used several sources to inform the search strategy: the PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health-related interventions (10), the Cochrane Handbook for Systematic Reviews of Interventions (11), the Institute of Medicine report 'Finding What Works in Health Care: Standards for Systematic Reviews' (12) and papers addressing search optimization and pertinent methodological issues (13). We also sought the assistance of a librarian, who helped to refine the search strategy. One author (SA) with biostatistical training oversaw the search process and developed the data collection systems.

The main electronic database search strategy was based on keywords and text words derived from the study's inclusion criteria. Synonyms and alternate terminology were identified; a comprehensive list of terms was created (Appendix) to help increase the sensitivity of the search and to account for variability in terminology. Terms were assembled into groups using the 'PICOS' approach (10). We used the Boolean operators 'AND' (to separate groups) and 'OR' (to separate terms within groups). Variations in grouping methods were tested to formulate syntax with reasonable specificity and sensitivity (e.g. (P ((IC) O) S) OR (P (IC) O)).

One author (CS) conducted preliminary searches in PubMed, EMBASE and CINAHL. The search syntax process was adapted for Cochrane Library and Web of Science. We customized the syntax for each database and

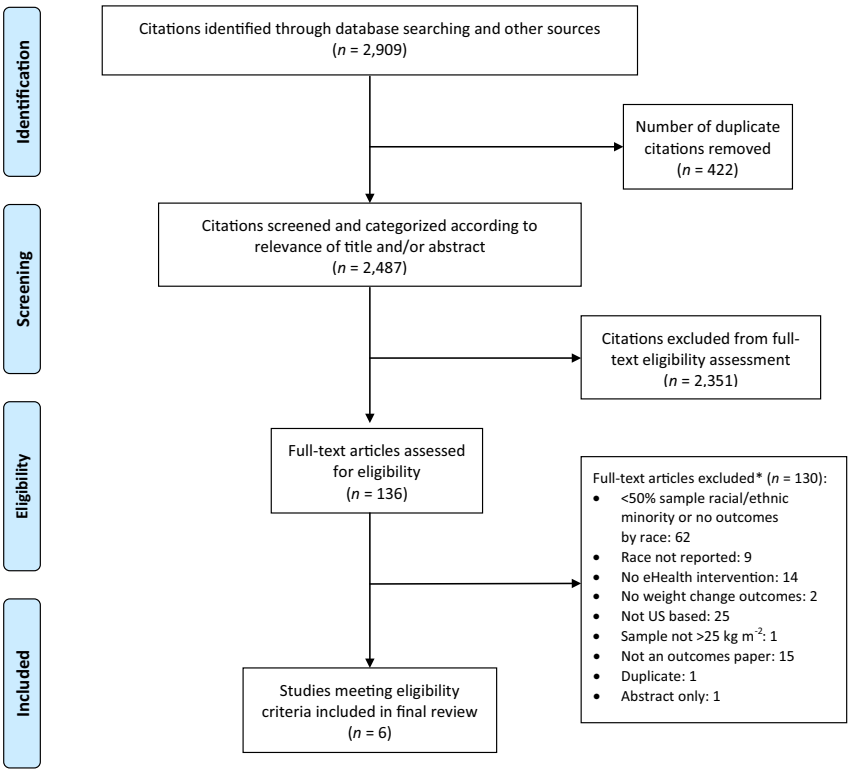

Figure 1 Search strategies.
*Categories are mutually exclusive. For studies that met more than one exclusion criterion, we present only one, following the order on the screening form.

controlled vocabulary terms and/or truncations where applicable. No date restrictions were applied. Process data were tracked using a software application and spreadsheet system that we adapted from another source (14). A flow diagram of the search process is shown in Fig. 1.

Study selection

After the initial search, one author (CS) removed duplicate citations and three reviewers (GGB, SA, CS) independently screened the titles and abstracts of the remaining studies in a blinded fashion. We used a coding system (11) to categorize citations as potentially eligible, related/relevant or clearly irrelevant. Articles coded as potentially eligible by at least one reviewer were identified and considered for full-text review. Two authors (GGB, IL) independently reviewed all full-text papers to evaluate their eligibility blinded to the other reviewer's evaluation. Reasons for exclusion were collated and compared by a single author (ML) and three authors (GGB, IL, ML) resolved any discrepancies via discussion and consensus (Fig. 1).

All records produced by electronic database searches ($n = 2{,}909$) were retrieved and collated using EndNote and Excel (CS). One study (15) was reported as a published abstract in a peer-reviewed journal; no additional data about the trial were available. Thus, this study was excluded. Based on the full-text review, a total of six citations met our inclusion criteria. One study (16) (originally excluded during full-text review for not reporting weight outcomes by race) was included because detailed outcomes were reported in a separate systematic review (17) identified through reference checks.

Data extraction

Data were collected and tabulated in forms adapted for this review. These data included study characteristics pertaining to methodology, participant characteristics, intervention components and weight change outcomes. Two authors (IL, ML) assessed the risk of bias of the identified studies, using an adapted version of the Risk of Bias Scale (12,18), an instrument based on the Consolidated Standards of Reporting Trials (CONSORT) criteria (19). Discrepancies in exclusion decisions were resolved through discussion and consensus. We rated each risk of bias component as present (1), absent (0) or unclear (0) and calculated the sum total for each study. We categorized scores for each study as high risk (0–3), medium risk (4–7) or low risk (8–10).

Given the few identified trials, we also will describe each trial in detail, particularly whether the respective interventions (i) utilize theory- and/or evidence-based components and (ii) were culturally adapted or tailored for the target population.

Results

We identified six trials: five that tested a weight loss intervention (16,20–23) and one that evaluated a weight loss maintenance intervention (5). All were conducted between 2005 and 2012. Five were randomized controlled trials (5,16,20,22,23) and one was a non-randomized prospective trial (21). All six trials were published as full reports in peer-reviewed journals. Three studies were conducted in samples in which ≥50% of participants were racial/ethnic minorities (20–22). The remaining three studies reported outcomes by racial/ethnic group (5,16,23).

Table 1 summarizes the characteristics of the six studies. The studies included 4,899 participants, 75% of whom were women. Blacks were the largest proportion of racial/ethnic minority participants. The mean age of participants was 46.6 years (range: 18–83 years). Two studies recruited participants entirely online (16,22) and one recruited participants from an integrated healthcare delivery system (16). One study was primary care-based (20), two were conducted in academic medical settings (5,21) and another in a military medical research centre (23). There was only one multisite, randomized controlled trial (5).

Two studies compared an eHealth intervention arm to a no-treatment control group (20,23). Other comparison arms included in-person nutrition education (21,22) or self-directed, information-based approaches via the web (16) or print (5). Svetkey *et al*. conducted a three-arm trial that compared an interactive technology-based intervention to a monthly personal contact group or a self-directed control arm (5).

Studies ranged from 6 to 30 months; three lasted more than 2 years (5,20,22). Participant retention was greater than 70% in all studies, except one (16). Rothert *et al*. reported a 6-month retention rate of 20.4%, with 84% attrition among blacks and 80.6% attrition among Hispanics.

All studies utilized web-based delivery of intervention content within the primary intervention group. Bennett *et al*. (20) used an intervention website that included skills training materials and self-monitoring functions, but also allowed participants to choose a parallel intervention offered through interactive voice response technology (IVR) and print materials. Several studies combined eHealth intervention content with that provided by a human counsellor (20–23). Two studies included eHealth interventions with no ongoing interpersonal contact (5,16), although Svetkey *et al* (5). contacted participants who became disengaged with the study website. Only one study reported associations between participant engagement and weight loss outcomes (23).

Risk of bias

Table 2 shows risk of bias data for each study. No study met all 10 criteria for low risk of bias. Studies scored generally in the medium- to low-risk range (median score = 7). One study had high risk of bias (16), two were at medium risk (21,22) and three were at low risk (5,20,23). Most studies did not include blinded assessors; examine associations between engagement and outcomes, or present effect sizes and precision estimates. All studies had at least 6 months of follow-up data, and most reported baseline results separately, used intent-to-treat principles, included a power analysis and assessed weight objectively.

Effectiveness of electronic health interventions for weight loss

Table 3 shows weight loss outcomes for each study. Three studies reported significantly greater weight loss outcomes for their eHealth intervention arm among racial/ethnic minority participants (16,20,22). The largest net weight change at 6 months was 2.08 kg (22); no study reported weight loss outcomes greater than 2.8 kg. Among studies reporting longer-term outcomes, only Bennett *et al*. reported significantly greater performance of the eHealth intervention, with 24-month net weight change of 1.03 kg (20). In general, weight loss outcomes were of low to moderate magnitude.

Weight loss intervention trials

Bennett *et al*. (20) conducted a pragmatic effectiveness trial of a 24-month weight loss intervention among 365 obese community healthcentre patients with hypertension. Participants were predominantly non-Hispanic black and Hispanic individuals. The intervention used evidence-based principles such as self-monitoring, social support, skills training and goal setting. Participants chose to interact with intervention content via a web-based interface or using a combination of IVR and print materials to track behavioural goals associated with weight control (e.g. walking 10,000 steps each day, no sugary drinks) based on the National Heart, Lung and Blood institute's DASH diet, a dietary pattern associated with both weight and blood pressure control (24). Participants also received 18 counselling calls from a community health educator (12 in year 1, six in year 2). The intervention was informed by both the social-ecological model and social cognitive theory and was designed for dissemination using the RE-AIM framework (25). All intervention materials were designed for users with lower literacy capabilities and were adapted to address the sociocultural characteristics of the target population. After 24 months of follow-up, intervention

Table 1 eHealth weight management interventions in racial/ethnic minority adults

Study	Participants						Study design		
	n (% female)	% Racial/ethnic minority	Mean age (year)	Age range (year)	Setting	Design	Trial length	Assessment schedule	Intervention arms
Bennett *et al.* (20)	365 (69%)	71% black 13% Hispanic	54.5	NR – minimum age of 21	Community health centres	RCT	24 months	Baseline; 6, 12, 18, 24 months	(a) eHealth: choice between website and IVR, and 18 phone counseling calls (b) Usual care
Hunter *et al.* (23)	446 (50%)	23% black 15% Hispanic	34	NR	Military medical research center	RCT	6 months	Baseline; 6 months	(a) eHealth: Biobehavioural Internet treatment (b) Usual care
Touger-Decker *et al.* (21)	137 (93%)	47% black and Hispanic 7% unknown and Asian Pacific Islander	46.5	NR – minimum age of 18	Academic medical center	Prospective non-randomized trial	3 months	Baseline; 6 weeks, 12 weeks, 6 months	(a) eHealth: Internet materials provided online, along with email and discussion forums with an RD and other participants (b) Saw RD for weekly group sessions
Williamson *et al.* (22)	57 (98%)	100% black	43.2	NR	Online	RCT	24 months	Baseline; 6, 12, 18, 24 months	(a) eHealth: websites with nutrition education and behaviour modification, counselling via email, weight and activity feedback on website, lesson plans and quizzes (b) Nutrition education from an RD, weight graph on website, given links to health-related websites
Rothert *et al.* (16)	2,862 (83%)	36% black 3% Hispanic	45	NR – minimum age of 18	Online	RCT	6 months	Baseline; 3 and 6 months	(a) eHealth: tailored expert web-based system (b) Information-only web-based materials
Svetkey *et al.* (5)	1,032 (63%)	38% black	55.6	28–83	Multisite academic medical centres	RCT	30 months	Baseline; 6, 12, 18, 24, 30 months	(a) Monthly personal contact (b) eHealth: unlimited access to interactive-based intervention (c) Self-directed control

IVR, interactive voice-activated technology; NR, not reported; RCT, randomized clinical trial; RD, registered dietitian.

Table 2 Risk of bias in included studies

Study	Baseline results reported separately per group	Randomization clearly described; adequately done	Drop out = OR < 20% for ≤6 months follow-up; ≤30% at >6 months follow-up	Assessor blinding	Weights ≥6 months after baseline	ITT analysis	eHealth engagement associated with weight outcomes	Estimated effect sizes and precision estimates presented	Power calculations shown; adequate power	Weight objectively measured	Total score
Bennett *et al.* (20)	1	1	1	0	1	1	0	1	1	1	8
Hunter *et al.* (23)	1	1	1	0	1	1	1	0	1	1	8
Rothert *et al.* (16)	1	0	0	0	1	1	0	0	0	0	3
Touger-Decker *et al.* (21)	1	0	0	0	1	0	0	0	1	1	4
Williamson *et al.* (22)	0	1	1	0	1	1	0	0	1	1	6
Svetkey *et al.* (5)	1	1	1	1	1	1	0	1	1	1	9

ITT, intention-to-treat; OR, odds ratio.

participants lost significantly more weight than controls (see Table 3). The study was not sufficiently powered to test for variation by intervention modality (web vs. IVR), but *post hoc* analyses revealed no differences.

Hunter *et al.* (23) recruited US Air Force personnel from two bases in San Antonio, TX. Participants were randomized to usual care or to a 6-month eHealth intervention that included daily self-monitoring of diet and physical activity behaviours and weekly weight monitoring. Participants then received weekly tailored feedback, as well as weekly lessons via the web. Interventionists also delivered two motivational counselling calls. The paper neither mentions using a theory to inform the intervention nor whether they made adaptations to the intervention to accommodate the US Air Force personnel. The intervention used evidence-based components such as self-monitoring, tailored feedback and motivational interviewing. Participants also received the LEARN manual, an evidence-based behavioural approach to weight management (26). At 6 months, in the total sample, the intervention produced larger weight loss outcomes than the control (see Table 3). However, 6-month outcomes among non-white participants did not significantly differ between treatment arms (17).

Touger-Decker *et al.* (21) conducted a 3-month non-randomized, prospective clinical trial of a workplace weight loss intervention, with follow-up at 6 months. Participants were overweight and obese academic healthcentre employees who were allocated by school campus to either an in-person arm or an Internet-based arm. All participants received identical intervention materials (either delivered in-person or online), and those in the Internet-based arm had access to email and discussion forums with a registered dietitian and other study participants. The paper does not describe any theoretical basis for the intervention. However, the intervention used theoretically informed, evidence-based components such as social support, goal setting and personalized diet guidelines based on recommendations of the National Cholesterol Education Program, the American Heart Association and the DASH diet (24). Weekly educational sessions included topics such as portion control, becoming more physically active, eating at restaurants, strategies for dealing with stress and relapse prevention. The use of an interactive Internet format for email and discussion rather than a strictly passive educational format is also a design choice supported by recent evidence (27). However, there were no statistically significant treatment effects on weight change at either 3- or 6-month follow-up.

Williamson *et al.* (22) hypothesized that an interactive eHealth intervention would produce greater weight loss among adolescents and their obese parents, compared with an education-only programme. Participants (including the child and his/her obese parent) were randomized to an

Table 3 Outcomes of eHealth weight management interventions in racial/ethnic minority adults

Study				Outcomes	
	Intervention arms	Retention (%)	Mean weight at baseline (kg)	Mean BMI at baseline (kg m^{-2})	Results (kg) and significance
Bennett *et al.* (20)	(a) eHealth: choice between website and IVR, and 18 phone counselling calls (b) Usual care	24 months (Total) 86.0 (a) 82.2 (b) 89.7	(a) 99.7 (b) 100.6	(a) 37.0 (b) 37.0	6 months: a > b (a) –1.25 (b) –0.13 12 months: a > b (a) –1.37 (b) –0.32 18 months: a = b (a) –1.28 (b) –0.33 24 months: a > b (a) –1.53 (b) –0.5
Hunter *et al.* (23)	(a) eHealth: Biobehavioural Internet treatment (b) Usual care	6 months (Total) 82.9 (a) 79.0 (b) 86.0	(Total) 87.0 (a) 87.4 (b) 87.4	(a) 29.4 (b) 29.3	6 months: a > b (a) –1.0 (b) +0.5 6 months, non-white: a = b (a) –1.0 (b) +0.5
Touger-Decker *et al.* (21)	(a) eHealth: Internet materials provided online, along with email and discussion forums with an RD and other participants (b) Saw RD for weekly group sessions	3 months (Total) 82.5% 6 months (Total) 69.3%	(Total) 90.3 (a) 84.8 (b) 95.9	NR	3 months: a = b (a) –2.2 (b) –1.47 6 months: a = b (a) –2.57 (b) –1.66
Williamson *et al.* (22)	(a) eHealth: websites with nutrition education and behaviour modification, counselling via email, weight and activity feedback on website, lesson plans and quizzes (b) Nutrition education from an RD, weight graph on website, given links to health-related websites	6 months (Total) 87.7 (a) 82.1 (b) 93.1 24 months (Total) 70.2 (a) 64.3 (b) 75.9	(Total) 101.2	(Total) 38.4	6 months: a > b (a) –2.43 (b) –0.35 24 months: a = b (a) –1.1 (b) –0.60
Rothert *et al.* (16)	(a) eHealth: tailored expert web-based system (b) Information-only web-based materials	3 months (Total) 30.3 6 months (Total) 20.4 (Black) 16.0 (Hispanic) 19.4	(a) 92.2 (b) 92.5	(a) 33.0 (b) 31.1 (Black and Hispanic subsample) 32.1	3 months: a > b (a) –2.6 (b) –1.2 6 months: a > b (a) –2.8 (b) –1.1 6 months Black and Hispanic: a > b (a) –1.21 (b) –0.48
Svetkey *et al.* (5)	(a) Monthly personal contact (b) eHealth: unlimited access to interactive-based intervention (c) Self-directed control	12 months (Total) 95.4 (a) 95.9 (b) 95.7 (c) 94.7 24 months (Total) 93.7 (a) 94.1 (b) 93.1 (c) 93.8	(Total) 96.7	(Total) 34.1	6 months: (a and b) > c 12 months: (a and b) > c 18 months: (a and b) > c 24 months: a > b > c 30 months (Total): a > (b and c) 30 months Black: a = b = c (a) –4.38 (b) –6.68 (c) –5.06

BMI, body mass index; IVR, interactive voice-activated technology; NR, not reported; RD, registered dietitian.

online health education arm without interactive components, or to a web-based intervention that provided nutrition education and counselling. Four face-to-face interpersonal counselling sessions were offered in both groups for obese parents during the first 12 weeks. Parents in both groups were provided with computers, free Internet access and training. They used the computer systems to access study materials and to email counsellors. The websites for both arms included culturally relevant information related to weight loss, such as recipes and links to other health websites. The counsellors for the interactive arm were trained to address culturally relevant dietary and physical activity related issues. The interactive behavioural intervention arm was based on family treatment methods developed by Epstein *et al* (28). It included self-monitoring of weight, physical activity and television watching via the web interface, and dietary monitoring with feedback based on the 'traffic light' diet (29). It featured skills training, problem solving and behavioural contracting with parents, adolescents and counsellors. At 6 months, weight losses among parents were greater in the eHealth intervention arm, but those differences did not persist at 24 months. (Outcomes among the adolescent children are outside the scope of this review.)

Rothert *et al*. (16) recruited overweight and obese participants online from a large integrated healthcare system. Participants were randomized to a web-based information-only arm or to a 6-week interactive web-based intervention that provided an individually tailored weight management plan. Both groups had follow-up at 3 and 6 months post-randomization, at which time self-reported weight was collected. The paper does not indicate whether cultural tailoring was incorporated into the study design; however, the intervention included several evidence-based weight loss principles (e.g. self-monitoring of diet and physical activity, social support, stress reduction and recognition of social cues) that are based on behaviour change theory (e.g. self-efficacy, self-control). In the information-only arm, participants accessed standardized weight loss and healthy living materials via the healthcare system website. As previously noted, participant attrition was high. At 3 and 6 months post-randomization, participants in the interactive intervention arm lost significantly more weight than those in the information-only (control) arm. After 6 months, weight loss among black and Hispanic participants was significantly greater in the intervention arm than the control arm (17).

Weight maintenance intervention trials

In the multisite Weight Loss Maintenance (WLM) trial (5), participants who lost ≥4 kg in a 6-month weight loss intervention were randomized to one of three 30-month maintenance intervention arms: a self-directed control intervention, an interactive web-based intervention or a personal contact intervention in which participants interacted with a counsellor in monthly face-to-face or telephone-based individual sessions. The interactive web-based intervention allowed unlimited access to a website with weight maintenance content, including goal setting, self-monitoring and social support features. The personal contact and interactive technology-based arms both incorporated theoretical constructs of motivation, support and problem solving. WLM specifically sought to include a significant percentage of black participants (38% of randomized participants were black). The study team sought input on cultural tailoring for the weight loss phase of the weight loss maintenance trial from a Minority Implementation Committee (30). Weight regain among those randomized to the web-based intervention arm did not significantly differ from the other two arms and race/ethnicity did not moderate treatment outcomes. However, from study entry, blacks had smaller absolute weight losses in the web-based intervention arm compared with the personal contact or the self-directed arms.

Discussion

eHealth weight management approaches show promising short-term efficacy among racial/ethnic minority populations. More than half of the identified trials reported significantly greater weight loss outcomes for their eHealth intervention arms relative to controls. However, these conclusions are drawn from a relatively limited evidence base. We found only six trials that met our primary inclusion criterion of being conducted among (or reporting outcomes for) racial/ethnic minorities – populations with the highest rates of obesity and obesity-associated chronic disease (2). Although the trials were generally well designed, the interventions themselves varied considerably. Compared with traditional individual and group-based intervention strategies, eHealth approaches produce relatively modest weight loss outcomes with undetermined clinical significance.

The inability to reliably produce clinically meaningful weight loss among racial/ethnic minorities has been a persistent public health challenge. Few traditional intervention trials conducted among racial/ethnic minorities have produced weight loss outcomes greater than 3 kg (20), even in the most intensive, well-controlled trials (31). At present, eHealth interventions appear to be similarly ill-equipped to overcome the modest weight losses produced by traditional intervention approaches. That said, few of the trials that we identified had a primary goal of improving weight loss outcomes in these populations. Thus, they did not employ strategies, such as cultural tailoring, that may improve outcomes among racial/ethnic minority participants. Of the trials that explicitly mentioned conducting formative work

to incorporate cultural considerations, one (20) was an effectiveness trial and the other (5) was a weight maintenance trial; these trials were not designed to offer insight about how to produce weight loss outcomes of large magnitude. Similarly, only a handful of studies reported outcomes by race/ethnicity. This limits our ability to draw conclusions about the efficacy of eHealth approaches in any specific racial/ethnic group or to compare outcomes by race/ethnicity.

Reporting outcomes by race/ethnicity is an important priority in future eHealth intervention research. For example, recent evidence suggests that blacks and Hispanics are disproportionately more likely than whites to own smart phones and to use their advanced data features (7,8). As intervention engagement is arguably the most important predictor of behaviour change outcomes in eHealth trials, intervention approaches that utilize smartphones might result in greater utility among racial/ethnic minority populations and therefore, better weight control outcomes (9).

Several points should be considered when interpreting these results. Most of the trials we identified were methodologically sound; we rated all but one study as having a low to medium risk of bias. Notably, and in contrast to the broader eHealth literature (1,9), most studies (with one exception (16)) reported high retention (>70%). This finding is especially noteworthy, given the high prevalence of attrition in eHealth interventions. Indeed, attrition rates of 40% to 50% or higher are not uncommon in eHealth interventions, and may be related to a host of participant- and design-level characteristics (9). High attrition rates can affect interpretability of study outcomes; however, we chose not to exclude studies from our review based solely on high attrition rates because such studies can help to inform future experimental designs and maximize the effectiveness of future eHealth interventions (32). The higher retention rates reported in most of the studies in our review might suggest the appropriateness of eHealth interventions for the target population; however, this conclusion should not be overstated. Rothert *et al.* reported significant rates of attrition, particularly among black participants (33), which they suggest might have resulted from the population's insecure Internet access. This factor was especially noteworthy in this study because it was the only trial to recruit and follow its participants entirely online and without interpersonal contact. Interpersonal contact is an important predictor of positive outcomes in eHealth trials (9). Indeed, with one exception (16), all studies reporting significant outcomes included additional support from a human counsellor.

Only three trials reported weight loss outcomes at 12 months or beyond (5,20,22), and only one of those reported significantly greater weight loss outcomes for the eHealth intervention at 24 months. However, the magnitude of the weight loss (–1.03 kg) was modest (20). Weight recidivism is a well-demonstrated characteristic of long-term weight loss outcomes. Trials of eHealth interventions with longer follow-up and/or maintenance interventions are necessary to enhance their potential for widespread dissemination, particularly in racial/ethnic minority populations (9).

Most of the trial samples were sociodemographically similar to those in the broader weight loss literature. This is concerning because a major promise of eHealth technologies is their potential for broad reach beyond those usually targeted via traditional in-person interventions (9). The identified trial samples were overwhelmingly female, middle-aged, and with one exception (20), had low rates of socioeconomic disadvantage. These characteristics do not provide insight into important subpopulations with elevated, and in some cases increasing, obesity risk. During the past decade, obesity has plateaued in several populations, with the notable exception of black and Hispanic men (2). Racial/ethnic minorities have the highest rates of childhood obesity, which often tracks into young adulthood (34). Socioeconomic disadvantage strongly patterns exposure to obesogenic risk factors and likely complicates treatment efforts (35). At present, we know little about how to reach, engage or treat these high-priority populations with eHealth approaches.

With one exception, all of the trials in the current review included randomized designs that compared an eHealth intervention to usual care, information-only control or a non-treatment control arm. No study compared an eHealth intervention to a non-eHealth approach, such as in-person counselling. Thus, while we have some preliminary evidence as to the absolute weight loss expected with eHealth trials, we do not yet know whether eHealth approaches represent a non-inferior treatment option, relative to in-person individual or group-based intervention approaches for racial/ethnic minority populations. This is an important consideration because dissemination has been a primary challenge for weight loss interventions, particularly those designed for racial/ethnic minority populations. Widespread dissemination of eHealth interventions may depend not only on demonstrations of their efficacy, but also on evidence supporting their comparative effectiveness, relative to established intervention approaches.

Participant engagement with intervention content is a robust predictor of weight loss outcomes in eHealth trials (1,9). Although there have been frequent calls to consistently report engagement outcomes, adherence to this recommendation varies widely, as do the specific engagement metrics that are reported (1,9). These challenges are well illustrated by the set of trials discussed here. No eHealth engagement metrics were reported for two studies (16,21). For the remaining trials, specific engagement metrics were quite variable. Bennett *et al.* reported that 40% of intervention participants tracked behaviour change goals at

least 50% of trial weeks, and 25% tracked at least 75% of trial weeks (20). Hunter *et al.* (23) reported that the average number of website logins was 49.1 (approximately twice weekly) over 6 months. These findings were similar to other studies (16,22) where, on average, participants logged into the study website weekly. Several studies reported declining engagement over time (9,16,22), a characteristic finding in eHealth studies (9). Rates of intervention engagement among racial/ethnic minorities seem to be reasonably similar to those in the broader eHealth weight loss literature (1). However, we could not determine differences in engagement by race/ethnicity with the limited data available. More standardization of engagement reporting and metrics is necessary to facilitate informed comparative analysis.

Finally, most of our identified trials were conducted in the early 2000s, when the Worldwide Web was the primary eHealth modality. Indeed, all of the trials delivered intervention content via the web, although Bennett *et al.* also used IVR technology. Most intervention websites were designed to share participant materials, and in some cases facilitate self-monitoring. Few intervention websites utilized the interactive features (e.g. video, chat, audio, social features, dynamic designs, extensive tailoring) that are now standard website features. As others have argued (9), the modest mean weight losses seen in the current review may be a function of the lack of advanced features in these interventions, rather than the sociodemographic characteristics of the trial samples. Thus, this generation of study findings may underestimate the true effect of eHealth intervention approaches in racial/ethnic minority populations.

Most of the identified trials predate the recent wave of mobile health (mHealth) technologies, which arguably began in 2007 with the release of Apple's iPhone. This is concerning because, as noted, we have witnessed dramatic changes in the nature of the 'digital divide'. Racial/ethnic minorities are more likely to own mobile devices and use advanced mobile features than whites (7,8). Racial/ethnic minorities have also been underrepresented in the first generation of mHealth weight control trials (36,37). Given that mobile devices may be a 'digital on-ramp' to the Internet for many in these populations, mHealth weight loss interventions are an important priority for future research (7,8). These technologies offer several advantages over web-based approaches (i.e. ubiquitous availability, low cost, limited barriers to entry and development costs, continuous and immediate proximity). However, the acceptability of mHealth technologies for use in weight loss interventions has yet to be established.

Our systematic review has several strengths, including a protocol that was consistent with PRISMA guidelines (38), and a comprehensive search strategy with numerous databases and database-specific search syntax. We rated studies on risk of bias, using a measure that allows for comparability with similar reviews. However, several features of our review might limit interpretations drawn from our findings. Our search strategy prioritized papers listed in leading databases. We could not fully identify non-peer-reviewed papers, and the lower likelihood of null findings appearing in the published literature may have affected our results. Additionally, our review was focused on interventions that targeted racial/ethnic adults; given the burden of obesity and high penetration of technology use among children and adolescents, understanding the efficacy of eHealth interventions in younger populations is a high priority. Similarly, this review was not specifically designed to investigate differences among racial/ethnic minority populations as the published literature in this area was sparse. More research is needed that can allow examination of subgroup differences. Additionally, future reviews might examine the prevalence of studies investigating eHealth approaches for diet and physical activity behaviours, as this was outside the scope of the current review.

In summary, there is a small, but growing literature detailing the efficacy of eHealth approaches for weight management in racial/ethnic populations. The extant evidence emerges from a wide range of study settings and intervention types. Nevertheless, many trials are methodologically sound and provide suggestive evidence that eHealth interventions can produce low magnitude, short-term weight loss among racial/ethnic minorities. Considering that these trials were conducted before the most recent proliferation of eHealth technologies and applications (notably, mobile applications), findings from the current review may underestimate the effects of modern eHealth weight loss interventions among racial/ethnic minority populations. eHealth approaches have great promise for public impact by delivering evidence-based intervention content at high reach and low cost. However, for the promise of eHealth to be realized, future research should explore the cultural appropriateness of eHealth interventions with racial/ethnic minority populations, employ more rigorous study designs with long-term follow-up and leverage recent technological advances more commonly used (e.g. smart phones) among racial/ethnic minority populations. By addressing these gaps in the literature and providing sufficient data in published findings to support replication and meta-analyses, the field will be more capable of evaluating the efficacy and effectiveness of eHealth interventions for clinically meaningful weight loss and maintenance among populations most at risk for obesity.

Conflict of interest statement

Dr. GG Bennett is a member of the scientific advisory board for Nutrisystem. No other conflicts of interest are declared.

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Appendix

Search strategy

Search syntax

All terms in quotation marks were searched as 'text word' in query unless indicated otherwise. Terms without quotes were searched for in either: 'all fields' or any controlled vocabulary identified in the database. Any unrecognized words were eliminated and synonyms added as necessary from the keyword collection. Grouping of terms was modified in searches that were too sensitive or too restrictive using the framework below.

1. Obesity [explosion / index term]
2. Obesity
3. 'obese'
4. overweight [explosion / index term]
5. overweight
6. 'weight-reduced'
7. 'ethnic'
8. 'race'
9. 'African American' [explosion/index term] or [Title/Abstract] or [Filter]
10. 'Hispanic' [explosion/index term] or [Title/Abstract] or [Filter]
11. Search # (all terms in section)
12. 'e-health' or [explosion/ index term]
13. 'ehealth' or [explosion/ index term]
14. 'electronic health'
15. 'telemedicine' [explosion or index term]
16. 'telemedicine'
17. 'telehealth'
18. 'mhealth'
19. 'm-health'
20. 'mobile health'
21. 'interactive media'
22. 'telephone' [explosion/ index term]
23. 'telephone'
24. 'telephone-based'
25. Search all terms (1–24)
26. 'phone-based'
27. 'internet' [explosion or index term]
28. 'internet'
29. 'internet-based' or [Title/abstract]
30. web
31. 'web-based'
32. 'website'
33. 'website-based'
34. 'e-mail'
35. 'email'
36. 'electronic mail'
37. 'e-mail-based'
38. 'computers' [explosion or index term]
39. 'computers'
40. 'computer'
41. 'computer-based'
42. online
43. 'wireless'
44. 'mobile phone'
45. 'cell phone'
46. 'cellular phone'
47. 'smartphone'
48. 'mobile device'
49. 'personal digital assistant'
50. 'pda'
51. 'interactive voice response'
52. 'ivr'
53. 'text message'
54. 'text messaging' [explosion or index term]
55. 'text messaging'
56. 'text message'
57. 'SMS'
58. 'iOTA'
59. 'bluetooth'
60. 'chat'
61. 'chat room'
62. 'instant message'
63. 'IM'
64. twitter
65. tweet
66. 'blog'
67. 'social network'
68. tailored
69. automated
70. individualized
71. programmed
72. remote
73. 'self-monitoring'
74. 'feedback' [explosion or index term]
75. 'feedback'
76. 'prompt'
77. 'reminder'
78. Search all terms (26–77)
79. 'weight loss' [explosion or index term]

80. 'weight loss'
81. 'weight reduction'
82. 'weight reduction programs/methods' [explosion or index term]
83. 'weight loss maintenance'
84. 'weight gain prevention'
85. 'obesity trials' [explosion or index term]
86. 'obesity reduction' [explosion or index term]
87. 'obesity prevention' [explosion or index term]
88. Search all terms (79–87)
89. 'intervention'[Title/Abstract]
90. Randomized [index term] or [Title/Abstract]
91. controlled [index term] or [Title/Abstract]
92. trial [index term] or [Title/Abstract]
93. Search all terms (89–94)
94. 'humans'[Filter] or [index term]
95. 'all adult'[Filter] or [index term]
96. 'English'[Filter] or [index term]
97. Search (#25 AND #75 AND #88 AND #93 AND #94–96)

Database-tailored search strategies

The search syntax and strategy applied to each database search considers relevant controlled vocabulary, filters, indexing and search features of the individual databases.
An example is provided below.

Database: PubMed

PICOS component	Database-tailored syntax (using Boolean operators)
Population	(Obesity[MeSH] OR Obesity[All Fields] OR 'obese'[All Fields] OR (overweight[MeSH] OR overweight[All Fields]) OR 'weight-reduced'[All Fields] OR 'ethnic'[All Fields] OR 'race'[All Fields] OR African American[MeSH] OR 'hispanic' OR 'latino' OR 'latina')
	AND
Intervention and comparator	(('e-health'[All Fields] OR 'ehealth'[All Fields] OR 'electronic health'[All Fields] OR 'telemedicine'[MeSH Terms] OR 'telemedicine'[All Fields] OR 'telehealth'[All Fields] OR (mhealth[All Fields] OR 'm-health'[All Fields] OR 'mobile health'[All Fields]) OR 'interactive media'[All Fields] OR ('telephone'[MeSH Terms] OR 'telephone'[All Fields]) OR 'telephone-based'[Text Word] OR 'phone-based'[All Fields]) OR (('internet'[MeSH Terms] OR 'internet'[All Fields]) OR 'internet-based'[All Fields]) OR (web[All Fields] OR 'web-based'[All Fields]) OR ('website'[All Fields] OR 'website-based'[All Fields]) OR ('e-mail'[All Fields] OR 'email'[All Fields] OR 'electronic mail'[All Fields] OR 'e-mail-based'[All Fields]) OR ('computers'[MeSH Terms] OR 'computers'[All Fields] OR 'computer'[All Fields]) OR 'computer-based'[All Fields] OR online[All Fields] OR 'wireless'[All Fields] OR ('mobile phone'[All Fields] OR 'cell phone'[All Fields] OR 'cellular phone'[All Fields] OR 'smartphone'[Text Word] OR 'mobile device'[Text Word] OR 'personal digital assistant'[Text Word] OR 'pda'[Text Word]) OR ('interactive voice response'[All Fields] OR 'ivr'[All Fields]) OR ('text message'[All Fields] OR ('text messaging'[MeSH Terms] OR 'text messaging'[All Fields] OR 'text message'[All Fields] OR 'SMS'[Text Word]) OR 'iOTA'[All Fields] OR 'bluetooth'[Text Word] OR ('chat'[All Fields] OR 'chat room'[All Fields]) OR 'instant message'[All Fields] OR 'IM'[All Fields]) OR (twitter[All Fields] OR tweet[Text Word]) OR 'blog'[All Fields] OR 'social network'[All Fields] OR (tailored[All Fields] OR automated[All Fields] OR individualized[All Fields] OR programmed[All Fields] OR remote[All Fields] OR 'self-monitoring'[All Fields] OR ('feedback'[MeSH Terms] OR 'feedback'[All Fields]) OR 'prompt'[All Fields] OR 'reminder'[All Fields]))))
	AND
Outcomes	('weight loss'[MeSH Terms] OR 'weight loss'[All Fields] OR 'weight reduction'[All Fields] OR 'weight reduction programs/methods'[Mesh Terms] OR 'weight loss maintenance'[All Fields] OR 'weight gain prevention'[All Fields] OR (('obesity'[MeSH Terms] OR 'obesity'[All Fields]) AND reduction[All Fields]) OR (('obesity'[MeSH Terms] OR 'obesity'[All Fields]) AND prevention[All Fields])))
	AND
Study design	(trial OR 'intervention'[Title/Abstract] OR 'peer review' OR randomized OR controlled OR trial)
	AND
Filters	'humans'[Filter]) AND 'all adult'[Filter]

PICOS, participants, intervention, control, outcome measures and study design.