eHealth interventions targeting nutrition, physical activity, sedentary behavior, or obesity in adults : a scoping review of systematic reviews

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Abstract

A vast body of evidence regarding eHealth interventions for nutrition, physical activity, sedentary behaviour and obesity exists. This scoping review of systematic reviews aimed to evaluate the current level of evidence in this growing field. Seven electronic databases were searched for systematic reviews published until 27th October 2019. The systematic reviews must have included adult participants only, and have evaluated eHealth behavioural interventions with the primary aim of changing nutrition, physical activity, sedentary behaviour or treating or preventing overweight and obesity. One hundred and six systematic reviews, published from 2006 to 2019, were included. Almost all (n=98) reviews evaluated the efficacy of interventions. Over half (n=61) included interventions focussed on physical activity, followed by treatment of obesity (n=28), nutrition (n=22), prevention of obesity (n=18) and sedentary behaviour (n=6). Many reviews (n=46) evaluated one type of eHealth intervention only, while 60 included two or more types. Most reviews (n=67) were rated as being of critically-low methodological quality. This scoping review identified an increasing volume of systematic reviews evaluating eHealth interventions. It highlights several evidence gaps (e.g. evaluation of other outcomes, such as reach, engagement or cost-effectiveness), guiding future research efforts in this area.

Introduction

The majority of people across the globe are insufficiently physically active, highly sedentary, and consume nutrient-poor energy-dense diets which can contribute to overweight or obesity.[1-7] Therefore, there is a need for approaches to address these modifiable behavioural health risk factors to treat and prevent obesity, and prevent non-communicable diseases such as cardiovascular disease, diabetes, depression and some types of cancers.[8-10] For example, prolonged sedentary behaviour and low physical activity, combined with dietary risk factors account for an estimated 10% of all disability-adjusted life-years globally, and high body mass index accounts for an estimated 3.8%.[11] Only those intervention types that can be implemented at a scale, at an affordable cost, while also demonstrating an adequate level of effectiveness will have a meaningful and sustained impact on the global burden of disease.[12] Given the immense scale of the problem, few approaches are better suited for this challenge than electronic health (eHealth) based intervention approaches.[13]

Globally, there is a commitment to the development and implementation of eHealth technologies for the detection, prevention and treatment of disease, and promotion of health and wellbeing [14]. eHealth is defined broadly as ‘‘the use of information and communications technology, especially the Internet, to improve or enable health and health care’’.[15] eHealth intervention technologies include websites, computers, smartphone applications (apps), mobile text messages, digital games, telehealth, or wearables/monitoring devices.[16] eHealth technologies provide a unique opportunity for implementation of population wide behavioural interventions targeting dietary intake, physical activity and sedentary behaviour. The internet is regularly accessed by an estimated 4 billion people worldwide,[17] and the adoption of new tools such as online social networks has been staggering (e.g., over 2.5 billion Facebook users).[18] High-speed broadband connections have allowed for information to be rapidly

transmitted in visually engaging formats, and the use of online videos and streaming services has become standard. It was not until 2007 that smartphones were introduced, but now more people access the internet using their phones than they do with a desktop computer.[19] With smartphones came the proliferation of apps, with half of the nearly 5 billion mobile phone users' worldwide using health apps.[20, 21] Such availability of health apps, in turn, stimulated the development of a new generation of activity trackers (e.g. Fitbit, Garmin) that automatically sync with smartphone apps, and that include functionalities that far surpass traditional pedometers.[22] Overall, the features and functionality of eHealth technologies offer excellent opportunities for the implementation of behaviour change interventions that are scalable and affordable.[13]

Despite the field of behavioural eHealth being relatively young, there has been an exponential increase in research in this area since the early 2000s.[23] A bibliometric analysis focusing on physical activity, sedentary behaviour and diet-related eHealth research demonstrated that in 2000, only nine papers were published in this area, but in 2016, 363 papers were published.[23] Of all 1712 publications included in that bibliometric analysis, 72% related to physical activity, 50% to weight, 36% to diet and 10% to sedentary behaviour.[23] Given the dramatic growth in publications, it is not surprising that the number of systematic reviews evaluating eHealth interventions targeting physical activity, sedentary behaviour, nutrition or obesity has also been increasing rapidly.

There have been many systematic reviews in this area, however many focus on a narrow sub-set of the eHealth evidence base, for example, focussing on particular population groups [24] or particular types of eHealth technology used, such as the use of online social networks [25], gamification [26], computer-tailoring [27], smartphone apps [28], web-based interventions [29, 30],

wearables [31], exergames [32], virtual reality [33] and more. While there has undoubtedly been an overlap between the different systematic reviews, there may also be gaps in the evidence synthesis. Without systematically identifying systematic reviews in this area, it is hardly possible to know if any specific, but nonetheless potentially important, research areas within this field have been missed by the reviews conducted to date. While other scoping reviews have been published in this field,[34-37] they have typically focused on one type of behavioural health risk factor, or one type of eHealth intervention. The authors are not aware of any scoping review on eHealth interventions targeting nutrition, physical activity, and sedentary behaviour simultaneously, nor that considers that interventions targeting these behavioural health risk factors commonly focus on the treatment or prevention of obesity. A scoping review can identify knowledge gaps in the evidence synthesised to date and therefore pave the way for further research. A scoping review can also highlight the strengths and limitations (e.g., methodological quality) of existing systematic reviews and the potential for a systematic review of systematic reviews.[38] Therefore, the aim of this scoping review was to examine the extent, range and methodological quality of systematic reviews undertaken to evaluate eHealth interventions targeting nutrition, physical activity, sedentary behaviour or obesity for adults (aged 18 years and older).

Methods

Protocol

A scoping review was undertaken using a predefined protocol following the methodological framework of Aksey and O'Malley.[38] The conduct and reporting of the scoping review is also consistent with the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist.[39] This review is part of a larger scoping review protocol which considered systematic reviews including participants of all

ages. The current paper presents results of systematic reviews of studies including adults only.

Eligibility criteria

The eligibility criteria were defined using the PICOS (Population, Intervention, Comparison, Outcome, Study Design) format. Eligibility for the review was:

Participants: Human participants of all ages were considered for inclusion in the larger scoping review protocol. This paper is restricted to systematic reviews that only included adults (aged 18 years or over or defined as 'adult' participants only by the authors). Systematic reviews including children only, or both adults and children, were excluded.

Interventions: eHealth behavioural interventions with the primary aim of changing nutrition, physical activity, sedentary behaviour or treating or preventing overweight and obesity. 'eHealth interventions' included those that used websites; computers; email; mobile/smartphones (apps or text messages); digital games; telehealth or monitoring devices as a component of the behavioural intervention. The included systematic reviews must have focused solely on eHealth interventions, but the individual eHealth interventions included in the systematic reviews did not need to be solely delivered using eHealth for inclusion.

Comparators: No specific comparators were required for inclusion in the scoping review.

Outcomes: No specific outcomes were required for inclusion in the scoping review, as the purpose of the review was to determine the scope of the available evidence evaluating eHealth interventions.

Study design: Systematic reviews of experimental studies (e.g., randomised control trials (RCT), pseudo-RCTs, pre-post studies), including meta-analyses, were eligible for inclusion in the review. Systematic reviews that contained experimental studies with observational or qualitative research were excluded.

Search strategy

The search strategy (Supporting Information: Table 1) was developed by an expert medical librarian, in consultation with the lead author (MH). The following databases were searched: MEDLINE (Ovid), MEDLINE in process (Ovid), EMBASE (Ovid), PsycINFO (Ovid), Scopus, CINAHL (EbscoHost) and Cochrane Library (Wiley). All sources were searched from 2000 to October 27, 2019, and limited to studies published in English. Restriction to English-only studies was necessary due to resource restrictions (e.g., lack of funds for translation). The year 2000 was selected based on a previous bibliometric review showing eHealth research in these disciplines was almost exclusively published from this year onwards.[23] The reference lists of all included systematic reviews were also searched.

Screening

Screening was managed using Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia). The lead author trained all reviewers in the inclusion criteria and screening process before the commencement of screening. Title, abstract and keywords of all identified papers were initially assessed by two independent reviewers, with potentially eligible papers proceeding to full-text screening. Two independent reviewers screened the full text of these papers, and reasons for exclusion were recorded. A third reviewer was consulted to resolve any disagreement.

Data extraction

Data were extracted by one reviewer and checked by a second independent reviewer using a data extraction form created especially for the review. The data extraction tool was pilot tested by the reviewers prior to implementation, and further refined for consistency and

efficiency. As the scoping review aimed to determine the overall number of systematic reviews (i.e. extent) and range of research undertaken, the following data were extracted:

- Systematic review characteristics (i.e., year published, review aim, search strategy, type of included studies).
- Participant inclusion criteria (e.g., age, gender/sex, disease states, region/country, ethnicity, socio-economic status).
- Intervention/comparators inclusion criteria (i.e., behavioural focus [nutrition, physical activity, sedentary behaviour or obesity treatment/prevention], type of eHealth interventions included [all types, or a sub-set]), and type(s) of control groups).
- Outcome inclusion criteria (i.e., outcomes of the review).
- Systematic review findings (i.e., number of included studies and presentation of findings).

Critical appraisal

The methodological quality of included systematic reviews was evaluated using A MeaSurement Tool to Assess systematic Reviews Version 2 (AMSTAR 2).[40] AMSTAR2 includes 16 items, with the developer of the tool suggesting that seven of the items be deemed as "critical", and nine as "non-critical", but that items' rating as critical or non-critical may be altered depending on the context of the individual review. For the current review, one of the seven critical items was deemed non-critical by the review team (Item 7 – justification for excluding individual studies – the team felt that this is not required by PRISMA reporting guidelines, so should not be considered a critical weakness). The six critical items and 10 non-critical items used to assess bias in this review are described in Table 1. As per the AMSTAR2 criteria, the overall confidence in the results of the included systematic reviews was rated as:

- High if it had no methodological weaknesses or one non-critical weakness
- Moderate if it had no critical flaw but more than one non-critical weakness.
- Low if it had one critical flaw, with or without non-critical weaknesses.
- Critically low if it had more than once critical flaw, with or without non-critical weaknesses.

Synthesis of results

A numerical analysis was undertaken to report the number of studies for each of the data extraction categories: systematic review characteristics, participant inclusion criteria, intervention/comparator inclusion criteria, outcome inclusion criteria, and review findings. In addition, the results are presented by methodological quality (high/moderate, low, critically-low) based on the AMSTAR2.

Results

Of the 1040 articles identified, 306 full-text articles were assessed for eligibility. One hundred and six systematic reviews specifically focused on the adult population and were included in this review (Figure 1).[27, 29-31, 41-148] Table 2 summarises the characteristics and inclusion criteria across the 106 included systematic reviews, by methodological quality. Supporting Information: Table 2 describes individual systematic review characteristics and inclusion criteria.

Methodological quality

Supporting Information: Table 3 provides the methodological findings across the 106 individual systematic reviews, by the 17 AMSTAR2 items. Overall, one review (0.9%) was deemed high quality, 14 reviews (13.2%) moderate quality, 24 low quality (22.6%), and 67

critically-low (63.2%). Due to the low number of high quality reviews, moderate and high quality are combined herein. Methodological strengths across the included reviews included disclosing conflicts of interest (n=88, 83.0%), performing study selection in duplicate (n=82, 77.4%), performing data extraction in duplicate (n=76, 71.7%), including the PICOS criteria in the study aim or inclusion criteria (n=74, 69.8%), appropriately considering heterogeneity across the included studies (n=72, 67.9%), and using satisfactory techniques to assess risk of bias (n=69, 65.1%). Methodological weaknesses across the individual systematic reviews included failing to explain the reasons for including specific study designs within the review (only 17 explained, 16.0%), failing to include a list of excluded studies with reasons for exclusion (only 10 included, 9.4%), and failing to include a list of funding sources for the included studies (only 6 included, 5.7%). Included reviews predominantly received a "partial yes" (n=59, 55.7%) or no (n=40, 37.7%) for the item pertaining to the search strategy, as few reviews (n=7, 7.0%) met the full AMSTAR2 criteria for a 'comprehensive search strategy'.

Systematic review characteristics

Most included reviews were published between 2016 and 2019 (n=64, 60.4%). No reviews were published prior to 2006. Figure 2 presents the methodological quality of included reviews by year of publication. The first moderate/high quality reviews were published in 2012 (n=3 or 37.5% of reviews published that year), with all prior reviews deemed critically-low quality. Notably, 2019 saw the highest number of systematic reviews published (n=27), which also resulted in the highest number of moderate to high quality reviews being published in any one year (n=6). Although a higher number of moderate to high quality reviews have been published over time, when considered as a proportion of reviews published in that year, 2012 was the year with the highest proportion of moderate to high

quality reviews (3 out of 8 reviews published, 37.5%). The years with the lowest proportion of critically-low quality reviews were 2015 and 2016 (n=3, 42.9% for both years).

Almost all of the included reviews focused on evaluating the efficacy or effectiveness of the interventions (n=98, 92.5%). All moderate/high quality reviews included evaluation of efficacy or effectiveness of interventions within their aim. Very few reviews' considered intervention reach (n=4, 4.8%), engagement (n=12, 11.3%), cost-effectiveness (n=3, 2.8%), and acceptability (n=2, 1.9%), described intervention components (n=7, 6.6%), evaluated intervention components associated with success (n=7, 6.6%) or use of behaviour change techniques in interventions (n=3, 2.8%).

Most included reviews search strategies included studies published up until 2016 to 2019 (n=53, 50.9%). All systematic review authors searched electronic databases as part of their search strategy, with a mean ± SD of 5.6±2.4 (Range 1-15) electronic databases searched. Moderate/high quality review authors searched a mean ± SD of 6.3±2.3 (Range 3-10) electronic databases. Searching reference lists of included studies was the next most prevalent (n=69, 65.1%) search strategy used, with a higher proportion of moderate/high quality reviews (n=12, 80%) applying this strategy.

Participant inclusion criteria

Most reviews included studies involving a broad age range of adults (n=98, 92.5%), with 11 of these moderate/high quality. Seven reviews specifically focused on older adult participants (generally aged 65 years and older), of which four were deemed moderate/high quality. Two reviews focused on young adults (generally aged 18 to 35 years), and both were of low/critically-low quality.

Only seven reviews' inclusion criteria limited participants' sex (i.e. female-only participants), with one of those being of moderate/high quality. All other included reviews (n=99, 93.4%) had no participant inclusion criteria related to gender or sex. Almost three-quarters of systematic reviews had no participant inclusion criteria related to weight status (n=77, 72.6%). Twenty nine of the included reviews (27.4%) included only studies which recruited participants who were overweight or obesity, of which five were of moderate/high quality. Most included systematic reviews (n=75, 70.8%) had no participant inclusion related to a specific disease or condition. Of the remaining reviews, a variety of different health conditions were a criterion for inclusion (e.g. diabetes, cardiovascular disease, cancer). The only moderate/high quality reviews that have been published with inclusion criteria related to a specific disease or condition included participants with cardiovascular disease (n=1), musculoskeletal disease (n=1) and mental health disorders (n=1). Very few included reviews had inclusion criteria related to participants' socioeconomic status (n=1, 0.9%), ethnicity (n=3, 2.8%) or geographical location (n=1, 0.9%).

Intervention/comparators inclusion criteria

Across the 106 included systematic reviews, over half (n=61, 57.5%) included interventions which focused on physical activity, while around one-quarter to one-fifth included interventions focused on the treatment of overweight/obesity (n=28, 26.4%), nutrition (n=22, 20.8%) and prevention of overweight/obesity (n=18, 17.0%). Few systematic reviews included interventions with a sedentary behaviour focus (n=6, 5.7%). Notably, there have been no moderate/high quality reviews published that included nutrition interventions, but 10 that included physical activity interventions, two sedentary behaviour interventions, and five the treatment or prevention of obesity.

Most of the included systematic reviews (n=81, 76.4%) focused on one component (i.e., nutrition, physical activity, sedentary behaviour *or* obesity only) within the included interventions. Twenty-five (23.6%) focused on two or more (e.g. nutrition *and* physical activity). Those that focused on two or more components tended to be of lower methodological quality, with only two of the 25 (8.0%) deemed moderate/high quality, compared to 13 of the 81 (16.1%) focusing on one component only.

Across the 106 included systematic reviews, in terms of the types of eHealth interventions included in the systematic reviews, many (n=36, 34.0%) did not specifically indicate within their inclusion criteria what specific type(s) of eHealth interventions were required for inclusion. Monitoring devices, such as pedometers or accelerometers, were an intervention inclusion criteria in 26 (24.5%) of included reviews, followed by smartphone apps (n=23, 21.7%) and websites (n=21, 19.8%). Thirty of the included systematic reviews only included interventions delivered solely using eHealth, five of which were deemed of moderate/high quality.

Further, 46 (43.4%) of the reviews focused on one type of eHealth intervention only. This included 21 reviews (19.8%) focusing on interventions delivered using monitoring devices (e.g. pedometers and accelerometers), seven (6.6%) on web-based interventions, five (4.7%) on telehealth, four (3.8%) on mobile applications, three (2.8%) on text messages and two (1.9%) on social media. The remaining 60 reviews (56.6%) included two or more types of eHealth interventions, with 36 of these not indicating within their inclusion criteria what specific type(s) of eHealth interventions were required for inclusion.

Just over half of the included reviews (n=60, 56.6%) did not require included studies to have a specific comparator group. These reviews tended to be graded as being of low quality (n=56). Of the 46 reviews that specified specific comparator groups for inclusion, 38 specified control groups, 22 a non-eHealth intervention, and ten another type of eHealth intervention.

Outcome inclusion criteria

Most of the included systematic reviews included studies that measured behavioural (physical activity n=55, 51.9%, nutrition n=17, 16.0%, sedentary behaviour n=8, 7.5%) or weight-related outcomes (n=48, 45.3%). Notably, there have been no moderate/high quality reviews published that considered nutrition outcomes, but eight that included physical activity outcomes, two sedentary behaviour, and six weight-related outcomes.

Study design inclusion criteria

Most of the included systematic reviews included RCTs (n=98, 92.5%), with 56 (52.8%) including only RCTs. All 15 moderate/high quality reviews included RCTs. A variety of other study designs were included within the systematic reviews including pseudo-RCTs, comparative studies with and without concurrent controls, and pre-post studies.

Systematic review findings

The mean number of studies included across the systematic reviews was 18.3 ± 13.7 (Range: 2-84). The critically-low quality studies included on average a larger number of studies (19.4 ± 12.8). Around 40% (n=43) of the included systematic reviews reported findings based on meta-analysis, while the remaining studies (n=60, 56.6%) used narrative summary only. The highest number of moderate/high quality studies synthesised evidence in both narrative and

meta-analysis (n=8), while six presented narratively findings only, and one meta-analysis only.

Discussion

This is the first scoping review, to our knowledge, to comprehensively examine the extent, range and methodological quality of systematic reviews undertaken to evaluate eHealth interventions targeting nutrition, physical activity, sedentary behaviour or obesity for adults. The scoping review identified 106 systematic reviews published from 2006 to 2019, with the number of published reviews increasing overtime. The methodological quality of the included systematic reviews was generally poor, with only 15 of the included reviews being deemed of moderate or high methodological quality and almost two-thirds deemed to be of critically-low quality (n=67).

The findings highlight a number of gaps and opportunities for future research in this field. In particular, the included systematic reviews predominantly focused (n=98) on determining the efficacy or effectiveness of included interventions. This suggests there is ample opportunity in future to conduct a systematic review of reviews of the effectiveness of eHealth interventions targeting nutrition, physical activity, sedentary behaviour or obesity in adults. However, findings suggested that few systematic reviews to date have examined other important aspects of eHealth interventions, such as usage and engagement, reach, cost-effectiveness and the evaluation of intervention components (e.g., self-monitoring, personalised feedback, gamification features). Given that few eHealth studies in this area have been able to demonstrate long-term maintenance of behaviour change, [98, 126] and low participant usage is a recognised barrier to long-term success of eHealth interventions, [149] it is surprising that so few systematic reviews have focused on intervention usage and

engagement. There is also a need for more research that deconstructs multi-component intervention and examines intervention components in isolation.[13] Typically eHealth interventions implement a plethora of components which makes it impossible to conclude what part of the intervention actually produced behaviour change. Finally, eHealth interventions are often presented as a type of intervention that can reach large numbers of people at a low cost,[13, 149] yet almost no studies examine to what extent these interventions can reach large populations in real-world circumstances, whether the reach is equitable, nor whether they can do so cost-effectively. [149] The lack of systematic reviews focusing on the key areas of intervention usage and engagement, reach, cost-effectiveness and the evaluation of specific intervention components, may be representative of a lack of original research relevant to these areas. However, the gap may also signify methodological differences within existing studies. For example, many evaluations of eHealth interventions report on usage (e.g. number of logins). However, the lack of comprehensive systematic reviews focusing on intervention usage or engagement may be due to the diverse and non-consistent definitions of intervention usage and engagement used across the eHealth research area [150], and therefore a potential barrier to undertaking such a review.

In the early days of behavioural eHealth research, an often-heard criticism was not being able to reach specific population subgroups (e.g., older adults, low socio-economic status), due to the 'Digital Divide'.[151] Yet, today the use of the internet, either via broadband connection or smartphone, is so high in most high-income countries,[19] that it offers unprecedented access to niche populations that are traditionally difficult to e reach in sufficient numbers using conventional approaches (e.g., face-to-face, group-based).[152] Often, people with rare diseases or conditions will also self-organise and start support groups on social media platforms, which can also be used to target the recruitment of these individuals into research studies.[153]

However, the vast majority of included reviews focused broadly on the adult population, with no other participant related inclusion criteria. Only a handful of included reviews have specifically targeted older adults (n = 7), young adults (n = 2), women (n = 7; but no studies focused on men), specific socio-economic status (n = 1), specific ethnicity (n = 1), specific geographical location (n = 1) diabetes (n = 2), cardiovascular disease (n = 4), COPD (n = 1), multiple sclerosis (n = 2), mental health disorders (n = 2), pregnant/post-partum (n = 4), cancer (n = 5), and musculoskeletal disease (n = 5). There is an absence of reviews focusing on lower- and middle income countries, which is notable given 82 % of global non-communicable disease deaths are attributed to low and middle income countries.[154] The only population subgroup that received a large amount of attention were individuals with overweight or obesity (n = 29), likely due to our inclusion of interventions focusing on the treatment of obesity. As such, there are great opportunities to further explore the population groups that these types of interventions may be effective for.

An interesting observation is the dominance of included studies that focussed on physical activity (n = 61) or obesity (n=46), compared to nutrition (n = 22) and sedentary behaviour (n = 6). There may be a number of explanations for this. Firstly, the number of researchers focussed on improving physical activity behaviour may be greater than those focused on changing diet/nutrition,[23] and the focus on improving sedentary behaviour is relatively new, and less established, compared to improving physical activity.[155] Secondly, self-monitoring is one of the most effective behaviour change techniques.[156] It is relatively easy to accurately assess change in physical activity (e.g., using pedometers or activity trackers) compared with diet.[157] The complexity of diets, including misreporting, day to day variation and errors in portion size estimation,[158] not only makes them harder to assess, but also harder to provide meaningful feedback to improve them (i.e., feedback on behaviour is another important behaviour change technique). As such, these barriers may have been responsible for the

development, evaluation, and implementation of fewer nutrition-focussed eHealth interventions, however recent advances in the field of technology-based dietary assessment (e.g., imaged-based methods, use of wearable devices) [159] may improve this in the future. Further, given none of the reviews that included nutrition intervention were rated at a high/moderate quality, it is important that higher quality systematic reviews or meta-analyses are undertaken that focus on eHealth behavioural nutrition interventions.

It is important to highlight that the eHealth field is broad and harbours a high level of diversity. For example, a web-based physical activity intervention may be operationalised entirely differently compared to an app-based or game-based physical activity intervention. Due to the extreme versatility the internet offers, even interventions within a single category (e.g., web-based interventions) may be operationalised and implemented in entirely different ways. This makes it difficult to draw conclusions about the efficacy/effectiveness of behavioural eHealth interventions in general. This is further hindered by the use of various definitions of eHealth in the systematic reviews. The high diversity in eHealth research is illustrated by systematic reviews either focussing exclusively on one type of eHealth intervention (n = 46), or focussing on more than one type of intervention (n = 60, with 36 of those not focussing on specific eHealth technologies). This further highlights the challenging nature of conducting a systematic review of reviews in this area of research. We therefore recommend that future systematic reviews limit themselves to one specific type of eHealth intervention and only include studies that broadly apply the same eligibility criteria, or greater attention is given to the similarities and differences between included eHealth interventions, and therefore suitability for comparison within evidence synthesis.

The AMSTAR2 tool was used to assess the methodological quality of studies included in the review. Very few systematic reviews (n=15) were classified as moderate or high quality, with almost two-thirds of included reviews (n=67) classified as critically low quality. Notably, despite the overall number of systematic reviews increasing over time, only the number, not proportion, of moderate or high quality reviews increased over time. This suggests that the poor methodological quality of systematic reviews remains a contemporary issue in this research area. However, it is important to acknowledge, that in order to be assessed as moderate or high quality the systematic review could not have a 'critical flaw'. If it had more than one critical flaw, it was automatically classified 'critically low quality' irrespective of the other 14 items of AMSTAR2. Therefore, the methodological quality tool used was strict, and potentially resulted in a greater number of studies being classified as low/critically low quality, than if another tool had been used. For example, many included systematic reviews had 'critical flaws' as they did not consider risk of bias when interpreting the results of the review, register their protocol prior to commencement of the review or conduct an adequate literature search. Many of the consistently identified methodological weaknesses could easily be overcome by reviewer teams, as they are likely an oversight in the reporting as opposed to a true methodological flaw. For example, reviewers could easily produce a list of excluded studies with reasons, as these data are routinely collected as part of the screening process, and if using a systematic review management system, such as Covidence, can be easily exported. Other methodological weaknesses could also be easily overcome in future systematic reviews by making minor changes to their methodological approach (e.g. adding funding source of the study to data extraction forms).

Overall, this scoping review has several strengths. It is the first scoping review to comprehensively evaluate the extent, range and methodological quality of systematic reviews

undertaken to evaluate eHealth interventions targeting nutrition, physical activity, sedentary behaviour or obesity for adults. The review was undertaken and reported as per PRISMA-ScR, used a comprehensive search strategy of seven databases to locate included studies, and used a reliable tool to evaluate the methodological quality of the included reviews (AMSTAR2). It therefore provides a comprehensive evaluation of the highest level of evidence (systematic reviews) relating to eHealth interventions in this research area. A potential limitation of the scoping review is that it includes systematic reviews published up until October 27th, 2019 only. Therefore, it is likely additional systematic reviews meeting the inclusion criteria have been published since this time. However, critical appraisal tools, such as AMSTAR2, now acknowledge the volume and complexity of work required to complete a review, and deem a search that was conducted within 24 months of completion of the review, as higher methodological quality. Another potential limitation is the use of AMSTAR2, while it is a reliable, and commonly used tool to assess methodological quality of systematic reviews, it is also very strict, and classifies some items as being of "critical" importance that are not required by the widely used Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist. As a result, studies which may have been reported adhering to PRISMA guidelines may still have been scored as being of low or even critically-low quality according to the AMSTAR2. This should be kept in mind when interpreting the large number of studies falling into the low and critically-low categories. In addition, this may have created a floor effect, potentially missing the variation in methodological quality across the reviews within these categories.

Overall, the volume of evidence synthesised in recent years relating to the evaluation of eHealth interventions targeting nutrition, physical activity, sedentary behaviour or obesity for adults is significant. Researchers within the field should be commended for the commitment

to evidence synthesis. However, in order to move the research field forward, and ensure that future systematic reviews can best inform the implementation of eHealth interventions into practice, our team proposes the following recommendations:

- Shift the focus from the volume of systematic reviews to the quality of systematic reviews. There is a particular need for high-quality systematic reviews focusing on eHealth nutrition interventions. A strategy to achieve this includes systematic review teams and journal editors and reviewers ensuring all published systematic reviews are undertaken and reported according to suitable guidelines, such as the PRISMA, or the Cochrane Handbook for Systematic Reviews of Interventions. Another strategy to achieve higher quality reviews is for greater international collaboration across review teams. This would allow sharing of resources and expertise to complete the systematic review, which may result in higher quality methodological practices.
- Focus on alternative outcomes to evaluating the 'efficacy' or 'effectiveness' of the interventions. Systematic review evidence is currently sparse relating to intervention reach, use and engagement, acceptability and cost-effectiveness, as well as what intervention components are associated with outcomes, and for whom the intervention is most effective. The current scoping review cannot determine if this scarcity of evidence is a result of a lack of published studies evaluating these outcomes and/or population groups, or lack of systematic reviews that have focused on these outcomes or population groups.
- Evaluate the use of eHealth interventions targeting nutrition, physical activity, sedentary behaviour or obesity in high risk or hard-to-reach population groups, given the potential of the intervention modality to overcome barriers to accessing traditional interventions approaches. There is also opportunity to further understand what population groups these types of interventions are effective for.

- Future systematic reviews of eHealth interventions better acknowledge the multifaceted differences between types of eHealth technologies. This can be achieved by limiting systematic reviews to one specific type of eHealth intervention, or by greater consideration being given to the similarity and comparability of eHealth interventions before grouping within evidence synthesis.
- Undertake a systematic review of systematic reviews focusing on the efficacy of eHealth interventions targeting nutrition, physical activity, sedentary behaviour or obesity for adults. Depending on the inclusion criteria, the review could include up to 98 systematic reviews, and provide a comprehensive synthesis of the existing evidence for the efficacy of this intervention approach.

References

1. Nielsen, S.J., Siega-Riz, A.M., and Popkin, B.M., Trends in energy intake in U.S. between 1977 and 1996: similar shifts seen across age groups. *Obes Res*, **2002**. *10*(5): p. 370-8.
2. Prevalence of physical activity, including lifestyle activities among adults--United States, 2000-2001. *MMWR Morb Mortal Wkly Rep*, **2003**. *52*(32): p. 764-9.
3. Hallal, P.C., Andersen, L.B., Bull, F.C., Guthold, R., Haskell, W., and Ekelund, U., Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*, **2012**. *380*(9838): p. 247-57.
4. Clark, B. and Sugiyama, T., Prevalence, trends, and correlates of sedentary behavior, in Physical activity, exercise, sedentary behavior and health. 2015, Springer. p. 79-90.
5. Bauman, A., Ainsworth, B.E., Sallis, J.F., et al., The descriptive epidemiology of sitting: a 20-country comparison using the International Physical Activity Questionnaire (IPAQ). *Am J Prev Med*, **2011**. *41*(2): p. 228-235.
6. Caballero, B., The global epidemic of obesity: an overview. *Epidemiol Rev*, **2007**. *29*(1): p. 1-5.
7. Imamura, F., Micha, R., Khatibzadeh, S., et al., Dietary quality among men and women in 187 countries in 1990 and 2010: a systematic assessment. *Lancet Glob Health*, **2015**. *3*(3): p. e132-e142.
8. World Health Organization and Food and Agriculture Organization of the United Nations, Diet, nutrition and the prevention of chronic diseases: Report of the joint WHO/FAO expert consultation, in WHO Technical Report Series, No. 916 (TRS 916). 2003, *WHO/FAO*: Switzerland.

9. World Cancer Research Fund and American Institute for Cancer Research, Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Vol. 1. 2007: Amer Inst for Cancer Research.

10. Lee, I.-M., Shiroma, E.J., Lobelo, F., et al., Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. **2012**. *380*(9838): p. 219-229.

11. Lim, S.S., Vos, T., Flaxman, A.D., et al., A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, **2012**. *380*(9859): p. 2224-2260.

12. World Health Organization, Global strategy on diet, physical activity and health. 2004, *WHO*: France.

13. Vandelanotte, C., Müller, A.M., Short, C.E., et al., Past, Present, and Future of eHealth and mHealth Research to Improve Physical Activity and Dietary Behaviors. *J Nutr Educ Behav*, **2016**. *48*(3): p. 219-228.e1.

14. World Health Organization, Global strategy on digital health 2020–2025. 2020, WHO: Switzerland.

15. Eng, T.R., The eHealth landscape: a terrain map of emerging information and communication technologies in health and health care. *The Robert Wood Johnson Foundation*, **2001**.

16. Heerden, A.v., Tomlinson, M., and Swartz, L., Point of care in your pocket: a research agenda for the field of m-health. *Bull World Health Organ*, **2012**. *90*: p. 393-394.

17. International Telecommunication Union. Statistics: Download time series of ICT data for the world, by geographic regions, by urban/rural area and by level of development, for the following indicators (2005-2020). Available online:

https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx Published 2019. Accessed December 14, 2020.

18. Statista. Number of monthly active Facebook users worldwide as of 3rd quarter 2020 (in millions). Available online: https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/ Published October, 2020. Accessed December 14, 2020.

19. Australian Communications and Media Authority, Communications Report 2018-19. 2020, *Australian Government*: Canberra, Australia.

20. Statista. Number of mobile phone users worldwide from 2015 to 2020 (in billions). Available online: https://www.statista.com/statistics/274774/forecast-of-mobile-phone-users-worldwide/ Published November, 2016. Accessed December 14, 2020.

21. European Data Protection Supervisor, Mobile Health: Reconciling technological innovation with data protection. 2015.

22. Alley, S., Schoeppe, S., Guertler, D., Jennings, C., Duncan, M.J., and Vandelanotte, C., Interest and preferences for using advanced physical activity tracking devices: results of a national cross-sectional survey. *BMJ Open*, **2016**. *6*(7): p. e011243.

23. Müller, A.M., Maher, C.A., Vandelanotte, C., et al., Physical Activity, Sedentary Behavior, and Diet-Related eHealth and mHealth Research: Bibliometric Analysis. *J Med Internet Res*, **2018**. *20*(4): p. e122.

24. Hammersley, L.M., Jones, A.R., and Okely, D.A., Parent-Focused Childhood and Adolescent Overweight and Obesity eHealth Interventions: A Systematic Review and Meta-Analysis. *J Med Internet Res*, **2016**. *18*(7): p. e203.

25. Maher, C.A., Lewis, L.K., Ferrar, K., Marshall, S., De Bourdeaudhuij, I., and Vandelanotte, C., Are health behavior change interventions that use online social networks effective? A systematic review. *J Med Internet Res*, **2014**. *16*(2): p. e40.

26. Looyestyn, J., Kernot, J., Boshoff, K., Ryan, J., Edney, S., and Maher, C., Does gamification increase engagement with online programs? A systematic review. *PloS one*, **2017**. *12*(3): p. e0173403.

27. Broekhuizen, K., Kroeze, W., van Poppel, M.N., Oenema, A., and Brug, J., A systematic review of randomized controlled trials on the effectiveness of computer-tailored physical activity and dietary behavior promotion programs: an update. *Ann Behav Med*, **2012**. *44*(2): p. 259-86.

28. Schoeppe, S., Alley, S., Van Lippevelde, W., et al., Efficacy of interventions that use apps to improve diet, physical activity and sedentary behaviour: a systematic review. *Int J Behav Nutr Phys Act*, **2016**. *13*(1): p. 127.

29. Vandelanotte, C., Spathonis, K.M., Eakin, E.G., and Owen, N., Website-Delivered Physical Activity Interventions. A Review of the Literature. *Am J Prev Med*, **2007**. *33*(1): p. 54-64.

30. Davies, C.A., Spence, J.C., Vandelanotte, C., Caperchione, C.M., and Mummery, W.K., Meta-analysis of internet-delivered interventions to increase physical activity levels. *Int J Behav Nutr Phys Act*, **2012**. *9*: p. 52.

31. Stephenson, A., McDonough, S.M., Murphy, M.H., Nugent, C.D., and Mair, J.L., Using computer, mobile and wearable technology enhanced interventions to reduce sedentary behaviour: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*, **2017**. *14*(1): p. 105.

32. Li, J., Theng, Y.-L., and Foo, S., Effect of exergames on depression: a systematic review and meta-analysis. *Cyberpsychol Behav Soc Netw*, **2016**. *19*(1): p. 34-42.

33. Ghiţă, A. and Gutiérrez-Maldonado, J., Applications of virtual reality in individuals with alcohol misuse: A systematic review. *Addict Behav*, **2018**. *81*: p. 1-11.

34. Arigo, D., Brown, M.M., Pasko, K., and Suls, J., Social Comparison Features in Physical Activity Promotion Apps: Scoping Meta-Review. *J Med Internet Res*, **2020**. *22*(3): p. e15642.

35. Aromatario, O., Van Hoye, A., Vuillemin, A., et al., How do mobile health applications support behaviour changes? A scoping review of mobile health applications relating to physical activity and eating behaviours. *Public Health*, **2019**. *175*: p. 8-18.

36. Lee, A.M., Chavez, S., Bian, J., et al., Efficacy and effectiveness of mobile health technologies for facilitating physical activity in adolescents: scoping review. *JMIR Mhealth Uhealth*, **2019**. *7*(2): p. e11847.

37. Kankanhalli, A., Saxena, M., and Wadhwa, B., Combined interventions for physical activity, sleep, and diet using smartphone apps: A scoping literature review. *Int J Med Inform*, **2019**. *123*: p. 54-67.

38. Arksey, H. and O'Malley, L., Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*, **2005**. *8*(1): p. 19-32.

39. Tricco, A.C., Lillie, E., Zarin, W., et al., PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*, **2018**. *169*(7): p. 467-473.

40. Shea, B.J., Reeves, B.C., Wells, G., et al., AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. **2017**. *358*: p. j4008.

41. Albergoni, A., Hettinga, F.J., La Torre, A., Bonato, M., and Sartor, F., The Role of Technology in Adherence to Physical Activity Programs in Patients with Chronic Diseases Experiencing Fatigue: a Systematic Review. *Sports Med Open*, **2019**. *5*(1): p. 41.

42. Allen, J.K., Stephens, J., and Patel, A., Technology-assisted weight management interventions: systematic review of clinical trials. *Telemedicine and e-Health*, **2014**. *20*(12): p. 1103-20.

43. Arem, H.I., M., A review of web-based weight loss interventions in adults. *Obes Rev*, **2011**. *12*(5): p. e236-43.

44. Bacigalupo, R., Cudd, P., Littlewood, C., Bissell, P., Hawley, M.S., and Buckley Woods, H., Interventions employing mobile technology for overweight and obesity: an early systematic review of randomized controlled trials. *Obes Rev*, **2013**. *14*(4): p. 279-91.

45. Beleigoli, A.M., Andrade, A.Q., Cancado, A.G., Paulo, M.N., Diniz, M.F.H., and Ribeiro, A.L., Web-Based Digital Health Interventions for Weight Loss and Lifestyle Habit Changes in Overweight and Obese Adults: Systematic Review and Meta-Analysis. *J Med Internet Res*, **2019**. *21*(1): p. e298.

46. Bennett, G.G., Steinberg, D.M., Stoute, C., et al., Electronic health (eHealth) interventions for weight management among racial/ethnic minority adults: a systematic review. *Obes Rev*, **2014**. *15 Suppl 4*: p. 146-58.

47. Berry, A., McCabe, C.S., Muir, S., and Walsh, N., Digital behaviour change interventions to facilitate physical activity in osteoarthritis: a systematic review. *Phys Ther Rev*, **2018**. *23*(3): p. 197-206.

48. Bossen, D., Veenhof, C., Dekker, J., and de Bakker, D., The effectiveness of self-guided web-based physical activity interventions among patients with a chronic disease: a systematic review. *J Phys Act Health*, **2014**. *11*(3): p. 665-77.

49. Bravata DM., Smith-Spangler C., Sundaram V., et al., Using pedometers to increase physical activity and improve health: a systematic review. *JAMA*, **2007**. *298*(19): p. 2296-304.

50. Brickwood, K.J., Watson, G., O'Brien, J., and Williams, A.D., Consumer-Based Wearable Activity Trackers Increase Physical Activity Participation: Systematic Review and Meta-Analysis. *JMIR MHealth and UHealth*, **2019**. *7*(4): p. e11819.

51. Buchholz, S.W., Wilbur, J., Ingram, D., and Fogg, L., Physical activity text messaging interventions in adults: a systematic review. *Worldviews Evid Based Nurs*, **2013**. *10*(3): p. 163-73.

52. Buckingham, S.A., Williams, A.J., Morrissey, K., Price, L., and Harrison, J., Mobile health interventions to promote physical activity and reduce sedentary behaviour in the workplace: A systematic review. *Digit Health*, **2019**. *5*: p. 2055207619839883.

53. Chang, T., Chopra, V., Zhang, C., and Woolford, S.J., The role of social media in online weight management: systematic review. *J Med Internet Res*, **2013**. *15*(11): p. e262.

54. Cheatham, S.W., Stull, K.R., Fantigrassi, M., and Motel, I., The efficacy of wearable activity tracking technology as part of a weight loss program: a systematic review. *J Sports Med Phys Fitness*, **2018**. *58*(4): p. 534-548.

55. Collins, C., Morgan, P., Neve, M., and Jones, P., Effectiveness of Web-based interventions in Achieving Weight Loss and Maintenance in Overweight and Obese Adults: A Systematic Review. *JBI Libr Syst Rev*, **2008**. *6*(12 Suppl): p. 1-10.

56. Connelly, J., Kirk, A., Masthoff, J., and MacRury, S., The use of technology to promote physical activity in Type 2 diabetes management: a systematic review. *Diabet Med*, **2013**. *30*(12): p. 1420-32.

57. Coons, M.J., Demott, A., Buscemi, J., et al., Technology Interventions to Curb Obesity: A Systematic Review of the Current Literature. *Curr Cardiovasc Risk Rep*, **2012**. *6*(2): p. 120-134.

58. Cooper, C., Gross, A., Brinkman, C., et al., The impact of wearable motion sensing technology on physical activity in older adults. *Exp Gerontol*, **2018**. *112*: p. 9-19.

59. Cotie, L.M., Prince, S.A., Elliott, C.G., et al., The effectiveness of eHealth interventions on physical activity and measures of obesity among working-age women: a systematic review and meta-analysis. *Obes Rev*, **2018**. *19*(10): p. 1340-1358.

60. de Vries, H.J., Kooiman, T.J., van Ittersum, M.W., van Brussel, M., and de Groot, M., Do activity monitors increase physical activity in adults with overweight or obesity? A systematic review and meta-analysis. *Obesity*, **2016**. *24*(10): p. 2078-91.

61. Dennett, R., Gunn, H., and Freeman, J.A., Effectiveness of and User Experience With Web-Based Interventions in Increasing Physical Activity Levels in People With Multiple Sclerosis: A Systematic Review. *Phys Ther*, **2018**. *98*(8): p. 679-690.

62. DiFilippo, K.N., Huang, W.H., Andrade, J.E., and Chapman-Novakofski, K.M., The use of mobile apps to improve nutrition outcomes: A systematic literature review. *J Telemed Telecare*, **2015**. *21*(5): p. 243-53.

63. Dorri, S., Asadi, F., Olfatbakhsh, A., and Kazemi, A., A Systematic Review of Electronic Health (eHealth) interventions to improve physical activity in patients with breast cancer. *Breast Cancer*, **2019**. *12*: p. 12.

64. Duff, O.M., Walsh, D.M., Furlong, B.A., O'Connor, N.E., Moran, K.A., and Woods, C.B., Behavior Change Techniques in Physical Activity eHealth Interventions for People With Cardiovascular Disease: Systematic Review. *J Med Internet Res*, **2017**. *19*(8): p. e281.

65. Eakin, E.G., Lawler, S.P., Vandelanotte, C., and Owen, N., Telephone interventions for physical activity and dietary behavior change: a systematic review. *Am J Prev Med*, **2007**. *32*(5): p. 419-34.

66. Elavsky, S., Knapova, L., Klocek, A., and Smahel, D., Mobile Health Interventions for Physical Activity, Sedentary Behavior, and Sleep in Adults Aged 50 Years and Older: A Systematic Literature Review. *J Aging Phys Act*, **2019**. *27*(4): p. 565-593.

67. Fakih El Khoury, C., Karavetian, M., Halfens, R.J.G., Crutzen, R., Khoja, L., and Schols, J., The Effects of Dietary Mobile Apps on Nutritional Outcomes in Adults with Chronic Diseases: A Systematic Review and Meta-Analysis. *J Acad Nutr Diet*, **2019**. *119*(4): p. 626-651.

68. Farzandipour, M., Nabovati, E., Anvari, S., Vahedpoor, Z., and Sharif, R., Phone-based interventions to control gestational weight gain: a systematic review on features and effects. *Inform Health Soc Care*, **2018**: p. 1-16.

69. Feter, N., Dos Santos, T.S., Caputo, E.L., and da Silva, M.C., What is the role of smartphones on physical activity promotion? A systematic review and meta-analysis. *Int J Publ Health*, **2019**. *64*(5): p. 679-690.

70. Gal, R., May, A.M., van Overmeeren, E.J., Simons, M., and Monninkhof, E.M., The Effect of Physical Activity Interventions Comprising Wearables and Smartphone Applications on Physical Activity: a Systematic Review and Meta-analysis. *Sports Med Open*, **2018**. *4*(1): p. 42.

71. Gasch, M., Dunleavy, G.J., Kyaw, B.M., Lean, M.E.J., and Nikolaou, C.K., Personalized Health, eLearning, and mHealth Interventions to Improve Nutritional Status. *Curr Nutr Rep*, **2016**. *5*(4): p. 295-306.

72. Goode, A., Hall, K.S., Batch, B.C., et al., The Impact of Interventions that Integrate Accelerometers on Physical Activity and Weight Loss: A Systematic Review. *Ann Behav Med*, **2017**. *51*(1): p. 79-93.

73. Goode, A.D., Reeves, M.M., and Eakin, E.G., Telephone-delivered interventions for physical activity and dietary behavior change: an updated systematic review. *Am J Prev Med*, **2012**. *42*(1): p. 81-8.

74. Griffiths, A.J., White, C.M., Thain, P.K., and Bearne, L.M., The effect of interactive digital interventions on physical activity in people with inflammatory arthritis: a systematic review. *Rheumatol Int*, **2018**. *38*(9): p. 1623-1634.

75. Haberlin, C., O'Dwyer, T., Mockler, D., Moran, J., O'Donnell, D.M., and Broderick, J., The use of eHealth to promote physical activity in cancer survivors: a systematic review. *Support Care Cancer*, **2018**. *26*(10): p. 3323-3336.

76. Hakala, S., Rintala, A., Immonen, J., Karvanen, J., Heinonen, A., and Sjogren, T., Effectiveness of technology-based distance interventions promoting physical activity: Systematic review, meta-analysis and meta-regression. *J Rehabil Med*, **2017**. *49*(2): p. 97-105.

77. Hakala, S., Rintala, A., Immonen, J., Karvanen, J., Heinonen, A., and Sjogren, T., Effectiveness of physical activity promoting technology-based distance interventions compared to usual care. Systematic review, meta-analysis and meta-regression. *Eur J Phys Rehabil Med*, **2017**. *53*(6): p. 953-967.

78. Hannan, A.L., Harders, M.P., Hing, W., Climstein, M., Coombes, J.S., and Furness, J., Impact of wearable physical activity monitoring devices with exercise prescription or advice in the maintenance phase of cardiac rehabilitation: systematic review and meta-analysis. *BMC Sports Sci Med Rehabil*, **2019**. *11*: p. 14.

79. Hutchesson, M.J., Rollo, M.E., Krukowski, R., et al., eHealth interventions for the prevention and treatment of overweight and obesity in adults: a systematic review with meta-analysis. *Obes Rev*, **2015**. *16*(5): p. 376-92.

80. Jahangiry, L., Farhangi, M.A., Shab-Bidar, S., Rezaei, F., and Pashaei, T., Web-based physical activity interventions: a systematic review and meta-analysis of randomized controlled trials. *Public Health*, **2017**. *152*: p. 36-46.

81. Jo, A., Coronel, B.D., Coakes, C.E., and Mainous, A.G., Is There a Benefit to Patients Using Wearable Devices Such as Fitbit or Health Apps on Mobiles? A Systematic Review. *Am J Med*, **2019**.

82. Job, J.R., Fjeldsoe, B.S., Eakin, E.G., and Reeves, M.M., Effectiveness of extended contact interventions for weight management delivered via text messaging: a systematic review and meta-analysis. *Obes Rev*, **2018**. *19*(4): p. 538-549.

83. Joiner, K.L., Nam, S., and Whittemore, R., Lifestyle interventions based on the diabetes prevention program delivered via eHealth: A systematic review and meta-analysis. *Prev Med*, **2017**. *100*: p. 194-207.

84. Joseph, R.P., Royse, K.E., and Benitez, T.J., A Systematic Review of Electronic and Mobile Health (e- and mHealth) Physical Activity Interventions for African American and Hispanic Women. *J Phys Act Health*, **2019**. *16*(3): p. 230-239.

85. Kelly, J.T., Reidlinger, D.P., Hoffmann, T.C., and Campbell, K.L., Telehealth methods to deliver multifactorial dietary interventions in adults with chronic disease: a systematic review protocol. *Syst Rev*, **2015**. *4*: p. 185.

86. Kelly, J.T., Reidlinger, D.P., Hoffmann, T.C., and Campbell, K.L., Telehealth methods to deliver dietary interventions in adults with chronic disease: a systematic review and meta-analysis. *Am J Clin Nutr*, **2016**. *104*(6): p. 1693-1702.

87. Khokhar, B., Jones, J., Ronksley, P.E., Armstrong, M.J., Caird, J., and Rabi, D., Effectiveness of mobile electronic devices in weight loss among overweight and obese populations: A systematic review and meta-analysis. *BMC Obes*, **2014**. *1*(1): p. 1-13.

88. Kirk, M.A., Amiri, M., Pirbaglou, M., and Ritvo, P., Wearable Technology and Physical Activity Behavior Change in Adults With Chronic Cardiometabolic Disease: A Systematic Review and Meta-Analysis. *Am J Health Promot*, **2019**. *33*(5): p. 778-791.

89. Kiss, N., Baguley, B.J., Ball, K., et al., Technology-Supported Self-Guided Nutrition and Physical Activity Interventions for Adults With Cancer: Systematic Review. *JMIR MHealth and UHealth*, **2019**. *7*(2): p. e12281.

90. Kodama, S., Saito, K., Tanaka, S., et al., Effect of Web-based lifestyle modification on weight control: a meta-analysis. *Int J Obes (Lond)*, **2012**. *36*(5): p. 675-85.

91. Kroeze, W., Werkman, A., and Brug, J., A systematic review of randomized trials on the effectiveness of computer-tailored education on physical activity and dietary behaviors. *Ann Behav Med*, **2006**. *31*(3): p. 205-23.

92. Larsen, R.T., Christensen, J., Juhl, C.B., Andersen, H.B., and Langberg, H., Physical activity monitors to enhance the daily amount of physical activity in elderly-a protocol for a systematic review and meta-analysis. *Syst Rev*, **2018**. *7*(1): p. 69.

93. Larsen, R.T., Christensen, J., Juhl, C.B., Andersen, H.B., and Langberg, H., Physical activity monitors to enhance amount of physical activity in older adults - a systematic review and meta-analysis. *Eur Rev Aging Phys Act*, **2019**. *16*: p. 7.

94. Lau, Y., Klainin-Yobas, P., Htun, T.P., et al., Electronic-based lifestyle interventions in overweight or obese perinatal women: a systematic review and meta-analysis. *Obes Rev*, **2017**. *18*(9): p. 1071-1087.

95. Levine, D.M., Savarimuthu, S., Squires, A., Nicholson, J., and Jay, M., Technology-assisted weight loss interventions in primary care: a systematic review. *J Gen Intern Med*, **2015**. *30*(1): p. 107-17.

96. Lewis, Z.H., Lyons, E.J., Jarvis, J.M., and Baillargeon, J., Using an electronic activity monitor system as an intervention modality: A systematic review. *BMC Public Health*, **2015**. *15*: p. 585.

97. Liu, F., Kong, X., Cao, J., et al., Mobile phone intervention and weight loss among overweight and obese adults: a meta-analysis of randomized controlled trials. *Am J Epidemiol*, **2015**. *181*(5): p. 337-48.

98. Lynch, E.A., Jones, T.M., Simpson, D.B., et al., Activity monitors for increasing physical activity in adult stroke survivors. *Cochrane Database Syst Rev*, **2018**. *7*: p. CD012543.

99. Lyzwinski, L.N., A systematic review and meta-analysis of mobile devices and weight loss with an Intervention Content Analysis. *J Pers Med*, **2014**. *4*(3): p. 311-385.

100. Mansi, S., Milosavljevic, S., Baxter, G.D., Tumilty, S., and Hendrick, P., A systematic review of studies using pedometers as an intervention for musculoskeletal diseases. *BMC Musculoskelet Disord*, **2014**. *15*: p. 231.

101. Manzoni, G.M., Pagnini, F., Corti, S., Molinari, E., and Castelnuovo, G., Internet-based behavioral interventions for obesity: an updated systematic review. *Clin Pract Epidemiol Ment Health*, **2011**. *7*: p. 19-28.

102. Marin, T.S., Kourbelis, C., Foote, J., et al., Examining adherence to activity monitoring devices to improve physical activity in adults with cardiovascular disease: A systematic review. *Eur J Prev Cardiol*, **2019**. *26*(4): p. 382-397.

103. McCarroll, R., Eyles, H., and Ni Mhurchu, C., Effectiveness of mobile health (mHealth) interventions for promoting healthy eating in adults: A systematic review. *Prev Med*, **2017**. *105*: p. 156-168.

104. Mertens, L., Braeken, M.A.K.A., and Bogaerts, A., Effect of Lifestyle Coaching Including Telemonitoring and Telecoaching on Gestational Weight Gain and Postnatal Weight Loss: A Systematic Review. *Telemed J E Health*, **2019**. *25*(10): p. 889-901.

105. Muellmann, S., Forberger, S., Mollers, T., Broring, E., Zeeb, H., and Pischke, C.R., Effectiveness of eHealth interventions for the promotion of physical activity in older adults: A systematic review. *Prev Med*, **2018**. *108*: p. 93-110.

106. Muellmann, S., Forberger, S., Mollers, T., Zeeb, H., and Pischke, C.R., Effectiveness of eHealth interventions for the promotion of physical activity in older adults: a systematic review protocol. *Syst Rev*, **2016**. *5*: p. 47.

107. Neve, M., Morgan, P.J., Jones, P.R., and Collins, C.E., Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis. *Obes Rev*, **2010**. *11*(4): p. 306-21.

108. Neville, L.M., Milat, A.J., and O'Hara, B., Computer-tailored weight reduction interventions targeting adults: a narrative systematic review. *Health Promot J Austr*, **2009**. *20*(1): p. 48-57.

109. Neville, L.M., O'Hara, B., and Milat, A., Computer-tailored physical activity behavior change interventions targeting adults: a systematic review. *Int J Behav Nutr Phys Act*, **2009**. *6*: p. 30.

110. Neville, L.M., O'Hara, B., and Milat, A.J., Computer-tailored dietary behaviour change interventions: a systematic review. *Health Educ Res*, **2009**. *24*(4): p. 699-720.

111. Nour, M., Chen, J., and Allman-Farinelli, M., Efficacy and External Validity of Electronic and Mobile Phone-Based Interventions Promoting Vegetable Intake in

Young Adults: Systematic Review and Meta-Analysis. *J Med Internet Res*, **2016**. *18*(4): p. e58.

112. Nour, M.M., Chen, J., and Allman-Farinelli, M., Efficacy and External Validity of Electronic and Mobile Phone-Based Interventions Promoting Vegetable Intake in Young Adults: A Systematic Review Protocol. *JMIR Res Protoc*, **2015**. *4*(3): p. e92.

113. Oliveira, C.B., Franco, M.R., Maher, C.G., et al., Physical Activity-Based Interventions Using Electronic Feedback May Be Ineffective in Reducing Pain and Disability in Patients With Chronic Musculoskeletal Pain: A Systematic Review With Meta-Analysis. *Arch Phys Med Rehabil*, **2018**. *99*(9): p. 1900-1912.

114. Oliveira, J.S., Sherrington, C., E.R.Y., Z., Franco, M.R., and Tiedemann, A., Effect of interventions using physical activity trackers on physical activity in people aged 60 years and over: a systematic review and meta-analysis. *Br J Sports Med*, **2019**. *09*: p. 09.

115. Park, S.H., Hwang, J., and Choi, Y.K., Effect of Mobile Health on Obese Adults: A Systematic Review and Meta-Analysis. *Healthc Inform Res*, **2019**. *25*(1): p. 12-26.

116. Patel, M.L., Wakayama, L.N., Bass, M.B., and Breland, J.Y., Motivational interviewing in eHealth and telehealth interventions for weight loss: A systematic review. *Prev Med*, **2019**. *126*: p. 105738.

117. Petersen, J.M., Prichard, I., and Kemps, E., A Comparison of Physical Activity Mobile Apps With and Without Existing Web-Based Social Networking Platforms: Systematic Review. *J Med Internet Res*, **2019**. *21*(8): p. e12687.

118. Podina, I.R. and Fodor, L.A., Critical review and meta-analysis of multicomponent behavioral e-health interventions for weight loss. *Health Psychol*, **2018**. *37*(6): p. 501-515.

119. Qiu, S., Cai, X., Chen, X., Yang, B., and Sun, Z., Step counter use in type 2 diabetes: a meta-analysis of randomized controlled trials. *BMC Med*, **2014**. *12*: p. 36.

120. Qiu, S., Cai, X., Wang, X., et al., Using step counters to promote physical activity and exercise capacity in patients with chronic obstructive pulmonary disease: a meta-analysis. *Ther Adv Respir Dis*, **2018**. *12*: p. 1753466618787386.

121. Raaijmakers, L.C., Pouwels, S., Berghuis, K.A., and Nienhuijs, S.W., Technology-based interventions in the treatment of overweight and obesity: A systematic review. *Appetite*, **2015**. *95*: p. 138-51.

122. Reed, V.A., Schifferdecker, K.E., Rezaee, M.E., O'Connor, S., and Larson, R.J., The effect of computers for weight loss: a systematic review and meta-analysis of randomized trials. *J Gen Intern Med*, **2012**. *27*(1): p. 99-108.

123. Richardson CR, Newton TL, JJ., A., Sen, A., Jimbo M, and Swartz AM, A meta-analysis of pedometer-based walking interventions and weight loss. *Ann Fam Med*, **2008**. *6*(1): p. 69-77.

124. Rintala, A., Hakala, S., Paltamaa, J., Heinonen, A., Karvanen, J., and Sjogren, T., Effectiveness of technology-based distance physical rehabilitation interventions on physical activity and walking in multiple sclerosis: a systematic review and meta-analysis of randomized controlled trials. *Disabil Rehabil*, **2018**. *40*(4): p. 373-387.

125. Roberts, A.L., Fisher, A., Smith, L., Heinrich, M., and Potts, H.W.W., Digital health behaviour change interventions targeting physical activity and diet in cancer survivors: a systematic review and meta-analysis. *J Cancer Surviv*, **2017**. *11*(6): p. 704-719.

126. Romeo, A., Edney, S., Plotnikoff, R., et al., Can Smartphone Apps Increase Physical Activity? Systematic Review and Meta-Analysis. *J Med Internet Res*, **2019**. *21*(3): p. e12053.

127. Rosenbaum, D.L., Piers, A.D., Schumacher, L.M., Kase, C.A., and Butryn, M.L., Racial and ethnic minority enrollment in randomized clinical trials of behavioural weight loss utilizing technology: a systematic review. *Obes Rev*, **2017**. *18*(7): p. 808-817.

128. Rosenbaum, S., Newby, J.M., Steel, Z., Andrews, G., and Ward, P.B., Online physical activity interventions for mental disorders: A systematic review. *Internet Interv*, **2015**. *2*(2): p. 214-220.

129. Ryan, K., Dockray, S., and Linehan, C., A systematic review of tailored eHealth interventions for weight loss. *Digit Health*, **2019**. *5*: p. 2055207619826685.

130. Schaffer, K., Panneerselvam, N., Loh, K.P., et al., Systematic Review of Randomized Controlled Trials of Exercise Interventions Using Digital Activity Trackers in Patients With Cancer. *J Natl Compr Canc Netw*, **2019**. *17*(1): p. 57-63.

131. Semper, H.M., Povey, R., and Clark-Carter, D., A systematic review of the effectiveness of smartphone applications that encourage dietary self-regulatory strategies for weight loss in overweight and obese adults. *Obes Rev*, **2016**. *17*(9): p. 895-906.

132. Seo, D.C. and Niu, J., Evaluation of Internet-Based Interventions on Waist Circumference Reduction: A Meta-Analysis. *J Med Internet Res*, **2015**. *17*(7): p. e181.

133. Sherifali, D., Nerenberg, K.A., Wilson, S., et al., The Effectiveness of eHealth Technologies on Weight Management in Pregnant and Postpartum Women: Systematic Review and Meta-Analysis. *J Med Internet Res*, **2017**. *19*(10): p. e337.

134. Sherrington, A., Newham, J.J., Bell, R., Adamson, A., McColl, E., and Araujo-Soares, V., Systematic review and meta-analysis of internet-delivered interventions providing

personalized feedback for weight loss in overweight and obese adults. *Obes Rev*, **2016**. *17*(6): p. 541-51.

135. Song, Y., Qu, J., Zhang, D., and Zhang, J., Feasibility and Effectiveness of Mobile Phones in Physical Activity Promotion for Adults 50 Years and Older: A Systematic Review. *Top Geriatr Rehabil*, **2018**. *34*(3): p. 213-222.

136. Stockwell, S., Schofield, P., Fisher, A., et al., Digital behavior change interventions to promote physical activity and/or reduce sedentary behavior in older adults: A systematic review and meta-analysis. *Exp Gerontol*, **2019**. *120*: p. 68-87.

137. Sypes EE, Newton G, and Lewis ZH, Investigating the Use of an Electronic Activity Monitor System as a Component of Physical Activity and Weight-Loss Interventions in Nonclinical Populations: A Systematic Review. *J Phys Act Health*, **2019**. *16*(4): p. 294-302.

138. Vaes, A.W., Cheung, A., Atakhorrami, M., et al., Effect of 'activity monitor-based' counseling on physical activity and health-related outcomes in patients with chronic diseases: A systematic review and meta-analysis. *Annals of Medicine*, **2013**. *45*(5-6): p. 397-412.

139. van den Berg, M.H., Schoones, J.W., and Vliet Vlieland, T.P., Internet-based physical activity interventions: a systematic review of the literature. *J Med Internet Res*, **2007**. *9*(3): p. e26.

140. Vanwormer, J.J., Boucher, J.L., and Pronk, N.P., Telephone-based counseling improves dietary fat, fruit, and vegetable consumption: a best-evidence synthesis. *J Am Diet Assoc*, **2006**. *106*(9): p. 1434-44.

141. Warner, M.M., Kelly, J.T., Reidlinger, D.P., Hoffmann, T.C., and Campbell, K.L., Reporting of Telehealth-Delivered Dietary Intervention Trials in Chronic Disease: Systematic Review. *J Med Internet Res*, **2017**. *19*(12): p. e410.

142. Weinstein, P.K., A review of weight loss programs delivered via the Internet [corrected] [published erratum appears in J CARDIOVASC NURS 2007 Mar-Apr;22(2):137]. *J Cardiovasc Nurs*, **2006**. *21*(4): p. 251-260.

143. Wieland, L.S., Falzon, L., Sciamanna, C.N., et al., Interactive computer-based interventions for weight loss or weight maintenance in overweight or obese people. *Cochrane Database Syst Rev*, **2012**(8): p. CD007675.

144. Willis, E.A., Szabo-Reed, A.N., Ptomey, L.T., Steger, F.L., Honas, J.J., Washburn, R.A., et al., Do weight management interventions delivered by online social networks effectively improve body weight, body composition, and chronic disease risk factors? A systematic review. *J Telemed Telecare*, **2017**. *23*(2): p. 263-272.

145. Willmott, T., Pang, B., Rundle-Thiele, S., and Badejo, A., Reported theory use in electronic health weight management interventions targeting young adults: a systematic review. *Health Psychol Rev*, **2019**. *13*(3): p. 295-317.

146. Willmott, T.J., Pang, B., Rundle-Thiele, S., and Badejo, A., Weight Management in Young Adults: Systematic Review of Electronic Health Intervention Components and Outcomes. *J Med Internet Res*, **2019**. *21*(2): p. e10265.

147. Woo J, Chen J, Ghanavati V, Lam R, Mundy N, and Li LC, Effectiveness of cellular phone-based interventions for weight loss in overweight and obese adults: a systematic review. *Orthop Muscular Syst*, **2013**. *3*: p. 141.

148. Young, C., Campolonghi, S., Ponsonby, S., et al., Supporting Engagement, Adherence, and Behavior Change in Online Dietary Interventions. *J Nutr Educ Behav*, **2019**. *51*(6): p. 719-739.

149. Michie, S., Yardley, L., West, R., Patrick, K., and Greaves, F., Developing and Evaluating Digital Interventions to Promote Behavior Change in Health and Health

Care: Recommendations Resulting From an International Workshop. *J Med Internet Res*, **2017**. *19*(6): p. e232.

150. Short, C.E., DeSmet, A., Woods, C., et al., Measuring Engagement in eHealth and mHealth Behavior Change Interventions: Viewpoint of Methodologies. *J Med Internet Res*, **2018**. *20*(11): p. e292.

151. Choi, N.G. and DiNitto, D.M., The Digital Divide Among Low-Income Homebound Older Adults: Internet Use Patterns, eHealth Literacy, and Attitudes Toward Computer/Internet Use. *J Med Internet Res*, **2013**. *15*(5): p. e93.

152. Jones, L., Jacklin, K., and O'Connell, M.E., Development and Use of Health-Related Technologies in Indigenous Communities: Critical Review. *J Med Internet Res*, **2017**. *19*(7): p. e256.

153. Burton-Chase, A.M., Parker, W.M., Hennig, K., Sisson, F., and Bruzzone, L.L., The use of social media to recruit participants with rare conditions: Lynch syndrome as an example. *JMIR Research Protocols*, **2017**. *6*(1): p. e12.

154. Lozano, R., Naghavi, M., Foreman, K., et al., Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancent*, **2012**. *380*(9859): p. 2095.

155. Tremblay, M.S., Aubert, S., Barnes, J.D., et al., Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act*, **2017**. *14*(1): p. 75.

156. Samdal, G.B., Eide, G.E., Barth, T., Williams, G., and Meland, E., Effective behaviour change techniques for physical activity and healthy eating in overweight and obese adults; systematic review and meta-regression analyses. *Int J Behav Nutr Phys Act*, **2017**. *14*(1): p. 42.

157. Butryn, M.L., Godfrey, K.M., Martinelli, M.K., Roberts, S.R., Forman, E.M., and Zhang, F., Digital self-monitoring: Does adherence or association with outcomes differ by self-monitoring target? *Obes Sci Pract*, **2020**. *6*(2): p. 126-133.

158. Burrows, T.L., Ho, Y.Y., Rollo, M.E., and Collins, C.E., Validity of Dietary Assessment Methods When Compared to the Method of Doubly Labeled Water: A Systematic Review in Adults. *Front Endocrinol*, **2019**. *10*(850).

159. Rollo M.E., Williams R.L., Burrows T., Kirpatrick S.I., Bucher T., and Collins C.E. What Are They Really Eating? A Review on New Approaches to Dietary Intake Assessment and Validation. *Curr. Nutr. Rep*. **2016**. 5:307–314.

Table 1 AMSTAR2 critical and non-critical items

Critical items	**Non-critical items**
Protocol registered before commencement of review	PICO used for research question/inclusion criteria
Adequacy of the literature search	Justification of study design inclusion
Risk of bias from individual studies being included in the review	Study selection completed in duplicate
Appropriateness of meta-analytical methods	Data extraction completed in duplicate
Consideration of risk of bias when interpreting the results of the review	Justification for excluding individual studies
Assessment of presence and likely impact of publication bias	Adequate description of included studies
	Sources of funding of included studies
	Impact of risk of bias on meta-analysis or other evidence synthesis assessed
	Satisfactory explanation and discussion of heterogeneity of results
	Conflicts of interest of authors declared

Table 2 Summary of characteristics of 106 systematic reviews evaluating eHealth interventions targeting nutrition, physical activity, sedentary behaviour and/or obesity for adults, by methodological quality

		All systematic reviews (n=106)	Moderate/ high (n=15)	Low (n=24)	Critically low (n=67)
Year of publication of review	2006-2010, *n (%)*	12 (11.3%)	0	0	12 (17.9%)
	2011-2015, *n (%)*	30 (28.3.4%)	6 (40.0%)	4 (16.7%)	20 (29.9%)
	2016–2019, *n (%)*	64 (60.4%)	9 (60.0%)	20 (83.3%)	35 (52.2%)
Aim(s) of the systematic review	Evaluation of intervention reach, *n (%)*	4 (3.8%)	0	0	4 (6.0%)
	Evaluation of efficacy/effectiveness, *n (%)*	98 (92.5%)	15 (100%)	22 (91.7%)	61 (91.0%)
	Evaluation of intervention engagement, *n (%)*	12 (11.3%)	2 (13.3%)	2 (8.3%)	8 (11.9%)
	Evaluation of intervention cost-effectiveness, *n (%)*	3 (2.8%)	0	0	3 (4.5%)
	Evaluation of intervention acceptability, *n (%)*	2 (1.9%)	2 (13.3%)	0	0
	Description of intervention components, *n (%)*	7 (6.6%)	0	1 (4.2%)	6 (9.0%)

	Evaluation of what intervention components are associated with success, *n (%)*	7 (6.6%)	0	1 (4.2%)	6 (9.0%)
	Evaluation of behaviour change techniques used in interventions, *n (%)*	3 (2.8%)	0	0	3 (4.5%)
	Other, *n (%)*	12 (11.3%)	1 (6.7%)	6 (25.0%)	5 (7.5%)
Search strategy: End date (year)	2004-2010 *n (%)*	16 (15.1%)	1 (6.7%)	0	15 (22.4%)
	2011-2015 *n (%)*	36 (34.0%)	5 (33.3%)	9 (37.5%)	22 (31.8%)
	2016–2019, *n (%)*	53 (50.9%)	9 (60.0%)	15 (62.5%)	29 (43.3%)
	Unclear	1 (0.9%)	0	0	1 (1.5%)
Search strategy: Number of electronic databases	Mean ± SD	5.6 ± 2.4	6.3 ± 2.3	5.5 ± 2.5	5.5 ± 2.3
	Range	1-15	3-10	3-15	1-14
Search strategy: Other strategies used	Search reference list of included studies, *n (%)*	69 (65.1%)	12 (80.0%)	18 (75.0%)	39 (58.2%)
	Consult experts in the field, *n (%)*	7 (6.6%)	1 (6.7%)	1 (4.2%)	5 (7.5%)
	Search citations of included studies, *n (%)*	12 (11.3%)	3 (20.0%)	4 (16.7%)	5 (7.5%)

	Search clinical trials registries, *n (%)*	7 (6.6%)	2 (13.3%)	2 (8.3%)	3 (4.5%)
	Search reference list of relevant systematic review, *n (%)*	14 (3.2%)	3 (20.0%)	5 (20.8%)	6 (9.0%)
	Online search engine (e.g. Google), *n (%)*	4 (3.8%)	2 (13.3%)	1 (4.2%)	1 (1.5%)
	Hand search of key journals, *n (%)*	4 (3.8%)	0	2 (8.3%)	2 (3.0%)
	No additional strategies beyond electronic database search, *n (%)*	26 (24.5%)	1 (6.7%)	3 (12.5%)	22 (32.8%)
Participant inclusion criteria: Age	All adults, *n (%)*	97 (91.5%)	11 (73.3%)	22 (91.7%)	64 (95.5%)
	Young adults only, *n (%)*	2 (1.9%)	0	1 (4.2%)	1 (1.5%)
	Older adults only, *n (%)*	7 (6.6%)	4 (26.7%)	1 (4.2%)	2 (3.0%)
Participant inclusion criteria: Gender/sex	No gender/sex inclusion criteria, *n (%)*	99 (93.4%)	14 (93.3%)	23 (95.8%)	62 (92.5%)
	Female only, *n (%)*	7 (6.6%)	1 (6.7%)	1 (4.2%)	5 (7.5%)
Participant inclusion criteria: Weight status	No inclusion criteria for weight status, *n (%)*	77 (72.6%)	10 (66.7%)	18 (75.0%)	49 (73.1%)
	Obese only, *n (%)*	3 (2.8%)	0	1 (4.2%)	2 (3.0%)
	Overweight and obese, *n (%)*	26 (24.5%)	5 (33.3%)	5 (20.8%)	16 (23.9%)

Participant inclusion criteria: Disease or condition	No disease/condition inclusion criteria, *n (%)*	75 (70.8%)	12 (80.0%)	16 (66.7%)	47 (70.2%)
	Diabetes, *n (%)*	2 (1.9%)	0	0	2 (3.0 %)
	Cardiovascular disease, *n (%)*	4 (3.8%)	1 (6.7%)	2 (8.3%)	1 (1.5%)
	Musculoskeletal disease, *n (%)*	4 (3.8%)	1 (6.7%)	0	3 (4.5%)
	Cancer, *n (%)*	5 (4.7%)	0	2 (8.3%)	3 (4.5%)
	Broadly chronic disease, *n (%)*	8 (7.6%)	0	2 (8.3%)	6 (9.0%)
	Chronic obstructive pulmonary disease, *n (%)*	1 (0.9%)	0	1 (4.2%)	0
	Multiple sclerosis, *n (%)*	2 (1.9%)	0	0	2 (3.0%)
	Mental health disorders, *n (%)*	1 (0.9%)	1 (6.7%)	0	0
	Pregnant/post-partum, *n (%)*	4 (3.8%)	0	1 (4.2%)	3 (4.5%)
Participant inclusion criteria: Socioeconomic status (SES)	No SES inclusion criteria *n (%)*	105 (99.1%)	14 (93.3%)	24 (100%)	67 (100%)
	Live in high-income countries, *n (%)*	1 (0.9%)	1 (6.7%)	0	0
	No ethnicity related inclusion criteria *n (%)*	103 (97.2%)	15 (100%)	24 (100%)	64 (95.5%)
	African American and Hispanic American, *n (%)*	1 (0.9%)	0	0	1 (1.5%)

Participant inclusion criteria: Ethnicity	"Ethnic minorities", *n (%)*	2 (1.9%)	0	0	2 (3.0%)
Participant inclusion criteria: Geographical location	No geographical inclusion criteria, *n (%)*	101 (95.3%)	14 (93.3%)	24 (100%)	63 (94.0%)
	United States of America, *n (%)*	4 (3.8%)	1 (6.7%)	0	0
	High-income OECD countries, *n (%)*	1 (0.9%)	0	0	4 (6.0%)
Intervention inclusion criteria: Behavioural focus[a]	Diet/Nutrition *n (%)*	22 (20.8%)	0	4 (16.7%)	18 (26.9%)
	Physical activity *n (%)*	61 (57.5%)	10 (66.7%)	11 (45.8%)	50 (59.7%)
	Sedentary behaviour *n (%)*	6 (5.7%)	2 (13.3%)	1 (4.2%)	3 (4.5%)
	Treatment of overweight and obesity *n (%)*	28 (26.4%)	3 (20.0%)	9 (37.5%)	16 (23.9%)
	Prevention of overweight and obesity *n (%)*	18 (17.0%)	2 (13.3%)	3 (12.5%)	13 (19.4%)
Intervention inclusion criteria: Behavioural focus-	One, *n (%)*	81 (76.4%)	13 (86.7%)	20 (83.3%)	48 (71.6%)
	Two or more, *n (%)*	25 (23.6%)	2 (13.3%)	4 (16.7%)	19 (28.4%)

number of behaviours					
Intervention inclusion criteria: eHealth intervention focus[a]	Website, *n (%)*	21 (19.8%)	2 (13.3%)	3 (12.5%)	16 (23.9%)
	Email, *n (%)*	12 (11.3%)	2 (13.3%)	0	10 (14.9%)
	Smartphone app, *n (%)*	23 (21.7%)	4 (26.7%)	6 (25.0%)	13 (19.4%_
	Text message, *n (%)*	17 (16.0%)	2 (13.3%)	3 (12.5%)	12 (17.9%)
	Digital games, *n (%)*	1 (0.9%)	0	0	1 (1.5%)
	Telehealth, *n (%)*	7 (6.6%)	0	1 (4.2%)	6 (9.0%)
	Social media, *n (%)*	3 (2.8%)	1 (6.7%)	0	2 (3.0%)
	Monitoring devices (pedometers, accelerometers) *n (%)*	26 (24.5%)	5 (33.3%)	9 (37.5%)	12 (17.9%)
	Other, *n %*	11 (10.4%)	3 (20.0%)	2 (8.3%)	6 (9.0%)
	General eHealth, *n (%)*	36 (34.0%)	5 (33.3%)	8 (33.3%)	23 (24.3%)
Intervention inclusion criteria: eHealth	One, *n (%)*	46 (43.4%)	6 (40.0%)	13 (54.2%)	27 (40.3%)
	Two or more, *n (%)*	60 (56.6%)	9 (60.0%)	11 (45.8%)	40 (59.7%)

intervention number of technologies					
Intervention inclusion criteria: Focus on	Interventions only delivered by eHealth *n (%)*	30 (28.3%)	5 (33.3%)	8 (33.3%)	17 (25.4%)
Intervention inclusion criteria: Comparator	No specific comparators, *n (%)*	60 (56.6%)	4 (26.7%)	11 (45.8%)	45 (67.2%)
Intervention inclusion criteria: Type of comparator[a]	Control, *n (%)*	38 (35.9%)	8 (53.3%)	13 (54.2%)	17 (25.4%)
	Another type of eHealth intervention, *n (%)*	10 (9.4%)	2 (13.3%)	3 (12.5%)	5 (7.5%)
	A non eHealth intervention, *n (%)*	22 (20.8%)	7 (46.7%)	4 (16.7%)	11 (16.4%)
Outcome inclusion criteria: Type of outcome measures[a]	Nutrition or diet, *n (%)*	17 (16.0%)	0	5 (20.8%)	12 (17.9%)
	Physical Activity, *n (%)*	55 (51.9%)	8 (53.3%)	12 (50.0%)	35 (52.2%)
	Sedentary behaviour, *n (%)*	8 (7.5%)	2 (13.3%)	2 (8.35)	4 (6.0%)

	Weight-related, *n (%)*	48 (45.3%)	6 (40.0%)	11 (45.8%)	31 (46.3%)
	Usage/engagement related, *n (%)*	1 (0.9%)	1 (6.7%)	0	0
	Cost-related outcome measure, *n (%)*	1 (0.9%)	0	1 (4.2%)	0
	Other, *n (%)*	14 (3.2%)	3 (20.0%)	4 (16.7%)	7 (10.5%)
	Unclear, *n (%)*	1 (0.9%)	0	0	1 (1.5%)
Study design inclusion criteria[a]	Randomised controlled trials, *n (%)*	98 (92.5%)	15 (100%)	222 (91.7%)	61 (9.0%)
	Pseudo-randomised controlled trials, *n (%)*	37 (34.9%)	7 (46.7%)	7 (29.2%)	23 (34.3%)
	Comparative studies with concurrent controls	23 (21.7%)	2 (13.3%)	6 (25.0%)	15 (22.4%)
	Comparative studies without concurrent controls, *n (%)*	13 (12.3%)	2 (13.3%)	3 (12.5%)	8 (11.9%)
	Case studies with either post-test or pre-test outcomes, *n (%)*	15 (14.2%)	4 (26.7%)	3 (12.5%)	8 (11.9%)
	Unclear (i.e. broadly experimental studies), *n (%)*	7 (6.6%)	0	2 (8.3%)	5 (7.5%)
Number of studies included	Mean ± SD	18.3 ± 13.7	17.2 ± 13.9	15.8 ± 16.3	19.4 ± 12.8
	Range	2-84	2-60	4-84	4-71
	Narrative summary only, *n (%)*	60 (56.6%)	6 (40%)	11 (45.8%)	43 (64.2)

Summary of findings	Meta-analysis only, *n (%)*	3 (2.8%)	1 (6.7%)	1 (4.2%)	1 (1.5%)
	Narrative summary and meta-analysis, *n (%)*	43 (40.6%)	8 (53.3%)	12 (50.0%)	23 (34.3%)

[a] Categories not mutually exclusive.