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Comparative effects of behaviour change techniques using eHealth and mHealth in promoting dietary behaviour: protocol for a systematic review and component network meta-analysis

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Key words: behaviour change techniques, component network meta-analysis, dietary behaviour, eHealth, mHealth

ABSTRACT

Introduction

Globally, it is estimated that dietary habits contribute to 22% of adult deaths and 15% of disability-adjusted life years, highlighting the critical role of dietary behaviour in public health. Despite the known benefits of healthy eating, many individuals find it challenging to change their diets for disease prevention. eHealth and mHealth interventions using behaviour change techniques (BCTs) have emerged as promising strategies to address this issue. However, the specific BCTs that are most effective in promoting dietary behaviour are not well-established. This systematic review and component network meta-analysis (CNMA) aims to estimate the effect size of each BCT on fostering healthy eating respectively.

Methods and analysis

We will include randomized controlled trials that assess the effects of eHealth and mHealth interventions on promoting changes in dietary behaviours among healthy adults. Studies with a minimum follow-up period of three weeks will be considered. Searches will be conducted in MEDLINE, EMBASE, the Cochrane Central Register of Controlled Trials, PsycInfo, and pre-registration sites. Two independent reviewers will conduct title and abstract screening, followed by a full-text review. Disagreements will be resolved through discussion or by consulting a third reviewer. The primary outcome is the dietary behaviour as measured by changes in the diet quality score and intake of specific food. Our data synthesis will apply a frequentist random-effects model for pairwise meta-analysis, NMA and an additive CNMA model to compute the effect size of each BCT. This methodological approach will reveal the positive and negative effects of each BCT and provide a ranking of these techniques, considering both direct and indirect evidence.

Ethics and dissemination

Ethical approval is not required for this review as it will use existing published data. The results will be submitted for publication in a peer-reviewed journal. The current protocol was submitted to PROSPERO on 16/01/2024 (CRD 42024502217).

Strengths and limitations of this study

- The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols statement was followed in preparing the protocol, and the appropriate systematic review and meta-analytic techniques would be applied.
- The importance of this study is identifying BCT to promote dietary behaviours through CNMA. This will enable the effective design of eHealth and mHealth interventions intended to promote dietary behaviours.
- Potential limitations include the presence of missing unpublished data.

INTRODUCTION

Rationale and Objective

Globally, poor dietary habits have been implicated in approximately 22% of adult deaths and contribute to 15% of disability-adjusted life years [1]. These habits particularly influence the prevalence of cardiovascular diseases, which are the leading causes of mortality exacerbated by obesity [2]. Despite the known benefits of healthy eating, individuals often struggle to make substantial and sustained changes in their dietary patterns to reduce disease risk [3].

To address this issue, eHealth and mHealth interventions that leverage technologies, such as smartphones and internet, have been extensively studied in recent decades [4]. Although systematic reviews have evidenced these interventions to be generally effective [5–7], heterogeneity in outcomes suggests a complex interplay of factors that influence their effectiveness.

One factor contributing to this heterogeneity is the complexity of eHealth and mHealth behaviour change interventions. Each intervention incorporated varying components, resulting in nonconstant effect sizes. In recent years, the determinants of health behaviour have been identified from the perspective of behavioural science and health psychology, and intervention studies aimed at behaviour change have proliferated [8]. Michie et al. systematised and standardised the elements of these behaviour change techniques (BCTs) to be reproducible and not reducible, publishing them in 2013 as the Behaviour Change Technique Taxonomy v1 (BCTTv1), which has gained international consensus [9]. BCTs are categorised into seven cluster solutions and 16 groups and further subcategorised into 93 specific techniques. Numerous attempts have been made to enhance eating habits through combined interventions that employ BCTs.

However, there is no consensus on the effectiveness of BCTs in promoting dietary behaviours. For example, systematic reviews have indicated that providing feedback, a form of BCT, is effective for behavioural modification [10,11]. Conversely, McDermott et al. contended that the same BCT can produce negative effects [12]. Additionally, Samdal et al. reviewed the possibility that presenting pros and cons can negatively affect behavioural change using pairwise meta-analysis and meta-regression analysis [13]. Therefore, clarifying the direction and magnitude of the effects of each BCT is crucial as this will enable the effective design of eHealth and mHealth interventions intended to promote dietary behaviour.

Studies that have assessed the effectiveness of the aforementioned BCTs typically rely on pairwise meta-analyses and meta-regression analyses to elucidate the efficacy of each BCT. However, these approaches have methodological limitations in accurately estimating the effect sizes of individual

BCTs. In this study, we will first verify the effectiveness of eHealth and mHealth interventions in promoting dietary behaviours using a pairwise meta-analysis. Subsequently, we will conduct a component network meta-analysis (CNMA), which decomposes interventions into diverse elements to estimate the effect size of each component. This analysis focused on randomised controlled trials (RCTs) and aimed to estimate the effect size of each BCT.

METHODS AND ANALYSIS

This systematic review protocol adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P) [14], PRISMA extension for network meta-analysis [15], and the Cochrane Handbook for Systematic Reviews of Interventions (Second Edition).

Eligibility criteria

Studies will be selected according to the criteria outlined below.

Study designs

RCTs, including cluster and crossover RCTs will be included if applicable. Quasi-experimental studies will be also excluded.

Participants

Healthy adults aged ≥18 years or older, including overweight or obese individuals but excluding those with specific diseases or conditions. For mixed-population studies, adult data will be extracted separately.

Interventions

We will consider eHealth and mHealth interventions encompassing electronic health records, telemedicine, mobile health apps, health information portals, and related technologies designed to encourage dietary behaviour. Studies focused on laboratory feeding trials not intended to assess behavioural change, those promoting prefabricated foods or meal-replacement drinks, and those testing dietary supplements such as fish oil were excluded from our analysis. Additionally, studies with follow-up data of minimum 3 weeks after randomization will be included.

Comparators

This study will include a range of comparators such as different eHealth or mHealth interventions, minimal interventions, usual care, and no interventions.

Outcomes

The primary outcome of this study is the change in dietary behaviours, evaluated through validated scores such as the Healthy Eating Index [16], Mediterranean Diet Score [17], and Dietary Approaches to Stop Hypertension (DASH) score [18], or through the consumption of specific foods that are recommended in the Mediterranean diet, such as fruits, vegetables, whole grains, nuts, legumes, seafood, and fish. These changes will be measured using methods such as dietary recall, dietary records, dietary history questionnaires, and food frequency questionnaires. Secondary outcomes will be

evaluated by integrating the same diet scores or the same types of foods. This study will also examine health-related outcomes, focusing on changes in body weight and body mass index (BMI).

Setting

This study will be not restricted by the type of setting.

Language

Articles reported in any language will be included, however, studies will be searched for in English.

Information sources

The following databases will be searched: MEDLINE, EMBASE, the Cochrane Central Register of Controlled Trials, PsycINFO, ClinicalTrials.gov, WHO International Clinical Trials Registry Platform (ICTRP), and University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR). Full database history from the beginning until 12 January 2024.

Search strategy

The search strategy will employ a combination of controlled terms and free-text words relevant to eHealth/mHealth and dietary behaviour (see Table 1 for PubMed strategy). Supplementary File 1 contains the full search strategies for the other databases. Before the final analysis, an updated search will ensure the inclusion of the latest studies.

Study records

Data management

Two independent reviewers (TF and NM) will screen the titles and abstracts of papers identified using the search strategies mentioned earlier. Duplicate papers will be removed and managed using the Rayyan [19].

Selection process

If the research title or abstract does not provide sufficient information to determine eligibility, the full paper will be assessed for acceptance or rejection. In case of a disagreement between the two reviewers, a senior researcher (TM) will be consulted for the final decision.

Data collection process

- Two independent reviewers (TF and NM) will extract data from the eligible studies, excluding BCTs, in duplicate. The first five titles will be screened in cooperation using a data collection form and discussed by the two reviewers.

- Data related to BCTs will be extracted by TF and checked by NM.
- Disagreements in data extraction will be resolved through discussion, and the study authors will be contacted to clarify uncertainties.

Data items

- A data collection sheet has been prepared and includes:

1. Title/author information
2. Year of publication
3. Study design
4. Eligibility criteria
5. Exclusion criteria
6. Participants' characteristics (demographics, number of endpoints, mean or median age, and sex ratio)
7. Settings
8. Intervention (including comparator) details for each arm (duration, frequency, and BCTs based on BCTTv1, provider, and delivery)
9. Outcome variables for each arm at the longest follow-up (variables and results)
10. Methods of dietary assessment
11. Dropout rate

Coding BCTs

The BCT will be coded only when there is clear evidence of inclusion. The 93 BCTs will be coded as present (1) or absent (0). The BCTs of the intervention and control groups will be identified separately.

Outcomes and prioritisation

Primary outcomes

The primary outcome will be dietary behaviour changes, assessed using the validated methods mentioned above. In cases where multiple dietary behaviour outcomes are reported in a single publication, priority will be given to the primary outcome identified in each article. If no prioritisation of outcomes is provided, preference will be given to composite scores (such as the Healthy Eating Index, the Mediterranean Diet Score, and DASH score) over individual food items. For studies reporting multiple timepoint measurements, we will use the score from the longest available follow-up period to ensure the assessment of sustained dietary behaviour changes.

Secondary outcomes

Secondary outcomes will assess changes in dietary intake and related health measures with a particular

focus on the following:

1. Daily intake of specific foods (vegetables, fruit, whole grains, nuts, seafood, and fish)
2. Combined daily fruit and vegetable intake
3. Each dietary quality score
4. Body weight (kg)
5. BMI (kg/m²), calculated from height and weight measurements obtained.

If multiple measurements are reported for all secondary outcomes, we will prioritize the data from the longest follow-up period to align with the assessment strategy of the primary outcome.

Risk of bias individual studies

Risk of bias will be assessed by two reviewers (TF and NM) independently using the Cochrane Collaboration tool (RoB 2.0) for the assessment of the risk of bias [20]. We will use "Bias in the effect of assignment to intervention" with domain 2. Disagreements will be resolved first by discussion and then by consulting a third author for arbitration.

Data synthesis

Pairwise meta-analysis

We will conduct a pairwise meta-analyses to assess the effectiveness of mHealth and eHealth interventions on each outcome when compared to comparator interventions (e.g. minimal intervention, no intervention, or usual care) when multiple studies containing comparable pairs were identified. Frequentist random effects models [21] will be used to combine the results. Different scores will be synthesised using SMD, and the same scores will be synthesised using MD along with 95% confidence intervals (CIs). Heterogeneity will be quantified using Cochrane's Q-test and Higgins' I^2 statistics.

Network meta-analysis (NMA)

We will perform a random-effects NMA assuming a common between-study variance across the entire network. We will estimate summary MD or SMD using 95% CIs. The surface under the cumulative ranking curve (SUCRA) will be used to assess the relative efficacy of interventions. We will assess the overall evidence for head-to-head comparisons of the interventions using network plots [15]. In addition, we will perform statistical evaluations of the incoherence in networks using global and local approaches. For the global approach, we will use a design-by-treatment interaction model to assess the incoherence [22]. For the local approach, Bucher's local inconsistency test will be used to quantify the incoherence of all triangular loops on the networks [23]. We will use "NMA" package with R statistical environment [24].

Component network meta-analysis (CNMA)

We will conduct a CNMA to assess the collective effectiveness of various BCTs. Additive CNMA will be performed under the assumption that the effects of combined treatments can be represented as the sum of their individual components [25]. This model will be particularly useful for isolating the effects of a single BCT when it is part of a combined intervention. The ranking of the BCTs will be estimated using P-scores [26]. The R statistical environment using the "netmeta" package [27] will support the CNMA. Discrepancies between the model-estimated effects and the observed data will be used to evaluate heterogeneity within the CNMA framework [28,29].

Narrative Synthesis

If quantitative synthesis is not feasible, owing to between-study heterogeneity or an insufficient number of studies, we will conduct a systematic narrative synthesis. This method will use information from the text and tables to summarise and describe the characteristics and findings of the incorporated studies.

Additional analysis

Subgroup analysis

For a more nuanced understanding of the effectiveness of the interventions' effectiveness, we will execute subgroup analyses within the meta-analysis for the primary outcome if a sufficient number of studies are involved. The factors considered for subgroup analyses will be participants' health status, with groups divided by mean subject BMI thresholds (≥ 30 or < 30), age categories (≥60 or <60 years), and intervention duration (≥3 or <3 months). Additionally, dietary assessment methods and the specific provider of the intervention will also be the criteria for subgroup analysis. This approach aims to discern the differential effects across various populations and intervention contexts.

Sensitivity analysis

Sensitivity analyses will be conducted to ascertain the stability of the findings. Priority will be given to eliminate studies with a high risk of bias. Further sensitivity assessments will review the robustness of the results across different levels of BCT classification (7, 16, or 93 categories), ensuring that the analysis accounts for the complexity and specificity of the behavioural interventions.

Small study effects

To investigate reporting bias, we will investigate studies with RCT protocols that meet the eligibility criteria but have not published their results. ClinicalTrials.gov, ICTRP, and UMIN-CTR will be screened for relevant information. Comparison-adjusted funnel plots and Egger's test will be used to assess potential publication and small-study biases.

Confidence in cumulative estimate

The overall certainty of evidence will be evaluated using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) framework for pairwise meta-analyses. For NMA, the Confidence in Network Meta-Analysis (CINeMA) approach will be considered [30–32].

Ethics and dissemination

Ethics approval is not required because this systematic review will solely use existing published data. The results will be submitted for publication in a peer-reviewed journal. Any significant protocol changes will be duly documented, providing a description of the change, its rationale, and the date of the amendment, all of which will be included in the final report.

Discussion

In this systematic review, we rigorously estimate the effect size of each BCT on dietary behaviour. Notably, no systematic review has explicitly addressed this objective, despite numerous publications focusing on BCTs for dietary behaviours. A critical aspect of this research lies in addressing the challenges inherent in deconstructing and comparatively analysing individual components within complex interventions. This is achieved by employing frequentist CNMA, a methodology that enables feasible and effective comparative analyses.

Deterioration of dietary behaviours is widely reported as a risk factor for various diseases [33,34]. However, improving these habits remains a formidable challenge for disease prevention. Therefore, estimating the individual effects of BCTs in this study is vital for designing effective strategies to foster behavioural changes. This approach not only contributes to the academic understanding of BCTs, but also has significant practical implications for public health intervention.

Authors' contributions:

TM is the guarantor. TF, NM, and TM drafted the manuscript. TF, NM, and TM contributed to the development of selection criteria, risk of bias assessment strategy, data extraction criteria, and search strategy. HN provided statistical expertise. All authors have read, provided feedback, and approved the final manuscript.

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Competing interests statement:

None declared.

Patient and public involvement

None

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403 Table 1 Search strategy for PubMed

Number	Search terms
#1	"mHealth"[Title/Abstract] OR ("mobile"[Title/Abstract] AND ("health"[Title/Abstract] OR "application"[Title/Abstract] OR "app"[Title/Abstract] OR "intervention"[Title/Abstract] OR "technology"[Title/Abstract] OR "phone"[Title/Abstract] OR "device*"[Title/Abstract])) OR "smartphone"[Title/Abstract] OR "smart phone"[Title/Abstract] OR "telemedicine"[MeSH Terms] OR "eHealth"[Title/Abstract] OR "SMS"[Title/Abstract] OR "iPod"[Title/Abstract] OR "iPad"[Title/Abstract] OR ("tablet"[Title/Abstract] AND ("device*"[Title/Abstract] OR "machine*" [Title/Abstract] OR "base*" [Title/Abstract] OR "computer*"[Title/Abstract])) OR "CD-ROM"[Title/Abstract] OR "multimedia"[Title/Abstract] OR "e-health"[Title/Abstract] OR "m-health"[Title/Abstract] OR "telemedicine"[Title/Abstract] OR (("digital"[Title/Abstract] OR "internet"[Title/Abstract]) AND ("intervention"[Title/Abstract] OR "base*"[Title/Abstract] OR "delivered"[Title/Abstract])) OR "web-base*"[Title/Abstract]
#2	"diet"[Title/Abstract] OR "dietary"[Title/Abstract] OR "eating"[Title/Abstract] OR "fruit*"[Title/Abstract] OR "vegetable*"[Title/Abstract] OR "BMI"[Title/Abstract] OR "Body Mass Index"[Title/Abstract] OR "body weight"[Title/Abstract] OR "health behavior change*"[Title/Abstract] OR "health behaviour change*"[Title/Abstract] OR "Body Mass Index"[MeSH Terms] OR "vegetables"[MeSH Terms] OR "fruit"[MeSH Terms] OR "diet"[Mesh Terms] OR "food*"[Title/Abstract] OR "food"[Mesh Terms] OR "Seafood"[Mesh Terms] OR "seafood" [Title/Abstract] OR "fish" [Title/Abstract] OR "Whole Grains"[Mesh Terms] OR "whole grain*"[Title/Abstract] OR "Nuts"[Mesh Terms] OR "legumes" [Title/Abstract] OR "Fabaceae"[Mesh Terms]
#3	("randomized controlled trial"[Publication Type] OR "controlled clinical trial"[Publication Type] OR "randomized"[Title/Abstract] OR "randomly"[Title/Abstract] OR "trial"[Title/Abstract] OR "groups"[Title/Abstract]) NOT ("animals"[MeSH Terms] NOT "humans"[MeSH Terms])
#4	#1 AND #2 AND #3

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Supplementary Table 1

Search strategy for EMBASE

Number	Search terms
#1	TI("mHealth") OR AB("mHealth") OR TI("mobile health") OR AB("mobile health") OR TI("smartphone") OR AB("smartphone") OR TI("mobile application") OR AB("mobile application") OR TI("mobile app") OR AB("mobile app") OR TI("mobile intervention") OR AB("mobile intervention") OR TI("mobile technology") OR AB("mobile technology") OR TI("mobile phone") OR AB("mobile phone") OR TI("mobile device") OR AB("mobile device") OR TI("telemedicine") OR AB("telemedicine") OR TI("eHealth") OR AB("eHealth") OR TI("SMS") OR AB("SMS") OR TI("iPod") OR AB("iPod") OR TI("iPad") OR AB("iPad") OR TI("CD-ROM") OR AB("CD-ROM") OR TI("multimedia") OR AB("multimedia") OR TI("e-health") OR AB("e-health") OR TI("m-health") OR AB("m-health") OR (TI("tablet") OR AB("tablet")) AND ((TI("device*") OR AB("device*")) OR (TI("machine*") OR AB("machine*")) OR (TI("base*") OR AB("base*")) OR (TI("computer*") OR AB("computer*"))) OR TI("telemedicine") OR AB("telemedicine") OR ((TI("digital") OR AB("digital")) OR (TI("internet") OR AB("internet"))) AND ((TI("intervention") OR AB("intervention")) OR (TI("base*") OR AB("base*")) OR (TI("delivered") OR AB("delivered"))) OR TI("web-base*") OR AB("web-base*") OR EMB("telemedicine") OR EMB("mobile health") OR EMB("electronic health")
#2	TI("diet") OR AB("diet") OR TI("dietary") OR AB("dietary") OR TI("eating") OR AB("eating") OR TI("fruit*") OR AB("fruit*") OR TI("vegetable*") OR AB("vegetable*") OR TI("BMI") OR AB("BMI") OR TI("Body Mass Index") OR AB("Body Mass Index") OR TI("body weight") OR AB("body weight") OR TI("health behavior change*") OR AB("health behavior change*") OR TI("health behaviour change*") OR AB("health behaviour change*") OR TI("food*") OR AB("food*") OR TI("seafood") OR AB("seafood") OR TI("fish") OR AB("fish") OR TI("Whole Grains") OR AB("Whole Grains") OR TI("nuts") OR AB("nuts") OR TI("legumes") OR AB("legumes") OR EMB("diet") OR EMB("vegetables") OR EMB("fruit") OR EMB("food")
#3	EMB.EXPLODE('randomized controlled trial')
#4	EMB('controlled clinical trial')
#5	TI(random*) OR AB(random*) OR OTI(random*)
#6	EMB('randomization')
#7	EMB('intermethod comparison')

#8	TI(placebo) OR AB(placebo) OR OTI(placebo)
#9	TI(compare) OR OTI(compare) OR TI(compared) OR OTI(compared) OR TI(comparison) OR OTI(comparison)
#10	((AB(evaluated) OR AB(evaluate) OR AB(evaluating) OR AB(assessed) OR AB(assess)) AND (AB(compare) OR AB(compared) OR AB(comparing) OR AB(comparison)))
#11	TI(open PRE/1 label) OR AB(open PRE/1 label) OR OTI(open PRE/1 label)
#12	TI((double OR single OR doubly OR singly) PRE/1 (blind OR blinded OR blindly)) OR AB((double OR single OR doubly OR singly) PRE/1 (blind OR blinded OR blindly)) OR OTI((double OR single OR doubly OR singly) PRE/1 (blind OR blinded OR blindly))
#13	EMB('double blind procedure')
#14	TI(parallel PRE/1 group*) OR AB(parallel PRE/1 group*) OR OTI(parallel PRE/1 group*)
#15	(TI(crossover) OR AB(crossover) OR OTI(crossover)) OR (TI('cross over') OR AB('cross over') OR OTI('cross over'))
#16	TI((assign* OR match OR matched OR allocation) NEAR/6 (alternate OR group OR groups OR intervention OR interventions OR patient OR patients OR subject OR subjects OR participant OR participants)) OR AB((assign* OR match OR matched OR allocation) NEAR/6 (alternate OR group OR groups OR intervention OR interventions OR patient OR patients OR subject OR subjects OR participant OR participants)) OR OTI((assign* OR match OR matched OR allocation) NEAR/6 (alternate OR group OR groups OR intervention OR interventions OR patient OR patients OR subject OR subjects OR participant OR participants))
#17	(TI(assigned) OR AB(assigned) OR OTI(assigned)) OR (TI(allocated) OR AB(allocated) OR OTI(allocated))
#18	TI(controlled NEAR/8 (study OR design OR trial)) OR AB(controlled NEAR/8 (study OR design OR trial)) OR OTI(controlled NEAR/8 (study OR design OR trial))
#19	(TI(volunteer) OR AB(volunteer) OR OTI(volunteer)) OR (TI(volunteers) OR AB(volunteers) OR OTI(volunteers))
#20	EMB('human experiment')
#21	TI(trial) OR OTI(trial)
#22	#3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21

#23	(TI(random* PRE/1 sampl* NEAR/8 ("cross section*" OR questionnaire* OR survey OR surveys OR database OR databases)) OR AB(random* PRE/1 sampl* NEAR/8 ("cross section*" OR questionnaire* OR survey OR surveys OR database OR databases)) OR OTI(random* PRE/1 sampl* NEAR/8 ("cross section*" OR "questionnaire*" OR survey OR surveys OR database OR databases))) NOT (EMB('comparative study') OR EMB('controlled study') OR TI('randomised controlled') OR AB('randomised controlled') OR OTI('randomised controlled') OR TI('randomized controlled') OR AB('randomized controlled') OR OTI('randomized controlled') OR TI('randomly assigned') OR AB('randomly assigned') OR OTI('randomly assigned'))
#24	(EMB('cross-sectional study') NOT (EMB.EXPLODE('randomized controlled trial') OR EMB('controlled clinical study') OR EMB('controlled study') OR TI('randomised controlled') OR AB('randomised controlled') OR OTI('randomised controlled') OR TI('randomized controlled') OR AB('randomized controlled') OR OTI('randomized controlled') OR TI('control group') OR AB('control group') OR OTI('control group') OR TI('control groups') OR AB('control groups') OR OTI('control groups')))
#25	((TI('case control*') OR AB('case control*') OR OTI('case control*')) AND (TI('random*') OR AB('random*') OR OTI('random*')) NOT (TI('randomised controlled') OR AB('randomised controlled') OR OTI('randomised controlled') OR TI('randomized controlled') OR AB('randomized controlled') OR OTI('randomized controlled')))
#26	((TI('systematic review') OR OTI('systematic review')) NOT (TI(trial) OR OTI(trial) OR TI(study) OR OTI(study)))
#27	(TI(nonrandom*) OR AB(nonrandom*) OR OTI(nonrandom*)) NOT (TI(random*) OR AB(random*) OR OTI(random*))
#28	TI('random field*') OR AB('random field*') OR OTI('random field*')
#29	TI('random cluster' NEAR/4 sampl*) OR AB('random cluster' NEAR/4 sampl*) OR OTI('random cluster' NEAR/4 sampl*)
#30	(AB(review) AND RTYPE(review)) NOT (TI(trial) OR OTI(trial))
#31	(AB('we searched') AND (TI(review) OR OTI(review) OR RTYPE(review)))
#32	AB('update review')
#33	AB(databases NEAR/5 searched)

#34	(TI(rat) OR OTI(rat) OR TI(rats) OR OTI(rats) OR TI(mouse) OR OTI(mouse) OR TI(mice) OR OTI(mice) OR TI(swine) OR OTI(swine) OR TI(porcine) OR OTI(porcine) OR TI(murine) OR OTI(murine) OR TI(sheep) OR OTI(sheep) OR TI(lambs) OR OTI(lambs) OR TI(pigs) OR OTI(pigs) OR TI(piglets) OR OTI(piglets) OR TI(rabbit) OR OTI(rabbit) OR TI(rabbits) OR OTI(rabbits) OR TI(cat) OR OTI(cat) OR TI(cats) OR OTI(cats) OR TI(dog) OR OTI(dog) OR TI(dogs) OR OTI(dogs) OR TI(cattle) OR OTI(cattle) OR TI(bovine) OR OTI(bovine) OR TI(monkey) OR OTI(monkey) OR TI(monkeys) OR OTI(monkeys) OR TI(trout) OR OTI(trout) OR TI(marmoset*) OR OTI(marmoset*)) AND EMB('animal experiment')
#35	(EMB('animal experiment') NOT (EMB('human experiment') OR EMB('human')))
#36	#23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35
#37	#22 NOT #36
#38	#1 AND #2 AND #37

Supplementary Table 2

Search strategy for the Cochrane Central Register of Controlled Trials

Number	Search terms
#1	MeSH descriptor: [Telemedicine] explode all trees
#2	“ mHealth”:ti,ab OR “mobile health”:ti,ab OR “smartphone”:ti,ab OR “smart phone”:ti,ab OR “mobile application”:ti,ab OR mobile NEXT app*:ti,ab OR “mobile intervention”:ti,ab OR “mobile technology”:ti,ab OR “mobile technologies”:ti,ab OR “mobile phone”:ti,ab OR “mobile device”:ti,ab OR “telemedicine”:ti,ab OR “eHealth”:ti,ab OR “SMS”:ti,ab OR “iPod”:ti,ab OR “iPad”:ti,ab OR “CD-ROM”:ti,ab OR “multimedia”:ti,ab OR “e-health”:ti OR “m-health”:ti,ab OR (“tablet” NEXT (device*:ti,ab OR machine*:ti,ab OR base:ti,ab OR based:ti,ab OR computer*:ti,ab)) OR ((“digital”:ti,ab OR “internet”:ti,ab) AND (“intervention”:ti,ab OR “base*”:ti,ab OR “delivered”:ti,ab))
#3	MeSH descriptor: [Vegetables] explode all trees
#4	MeSH descriptor: [Fruit] explode all trees
#5	MeSH descriptor: [Food] explode all trees
#6	MeSH descriptor: [Diet] explode all trees
#7	Diet*:ti,ab OR “dietary”:ti,ab OR “eating”:ti,ab OR fruit*:ti,ab OR vegetable*:ti,ab OR “BMI”:ti,ab OR “Body Mass Index”:ti,ab OR “body weight”:ti,ab OR health NEXT behavior NEXT change*:ti,ab OR health NEXT behaviour NEXT change*:ti,ab OR food*:ti,ab OR “seafood”:ti,ab OR “fish”:ti,ab OR whole NEXT

	grain*:ti,ab OR Nut*:ti,ab OR "legumes":ti,ab
#8	(#1 OR #2) AND (#3 OR #4 OR #5 OR #6 OR #7)

Supplementary Table 3

Search strategy for PsycINFO

Number	Search terms
#1	"mHealth" OR "mobile health" OR "smartphone" OR "smart phone" OR "mobile application" OR "mobile app" OR "mobile intervention" OR "mobile technology" OR "mobile technologies" OR "mobile phone" OR "mobile device" OR "telemedicine" OR "eHealth" OR "SMS" OR "iPod" OR "iPad" OR "CD-ROM" OR "multimedia" OR "e-health" OR "m-health" OR ("tablet" AND ("device*" OR "machine*" OR "base*" OR "computer*")) OR "telemedicine" OR (("digital" OR "internet") AND ("intervention" OR "base*" OR "delivered")) OR "web-base*" OR SU.EXACT("Telemedicine")
#2	"diet" OR "dietary" OR "eating" OR "fruit*" OR "vegetable*" OR "BMI" OR "Body Mass Index" OR "body weight" OR "health behavior change*" OR "health behaviour change*" OR "food*" OR "Seafood" OR "seafood" OR "fish" OR "whole grain*" OR "Nut*" OR "legumes" OR SU.EXACT("Diets") OR SU.EXACT("Food")
#3	SU.EXACT("Treatment Effectiveness Evaluation") OR SU.EXACT.EXPLODE("Treatment Outcomes") OR SU.EXACT("Placebo") OR SU.EXACT("Followup Studies") OR placebo* OR random* OR "comparative stud*" OR clinical NEAR/3 trial* OR research NEAR/3 design OR evaluat* NEAR/3 stud* OR prospectiv* NEAR/3 stud* OR (singl* OR doubl* OR trebl* OR tripl*) NEAR/3 (blind* OR mask*)
#4	#1 AND #2 AND #3

Supplementary Table 4

Search strategy for Clinicaltrials.gov

Number	Search terms
#1	mHealth OR "mobile health" OR smartphone OR "mobile app" OR eHealth OR telemedicine OR web-based OR internet-based
#2	diet OR eating OR dietary OR "Body Mass Index" OR BMI OR "body weight" OR vegetable OR fruit OR fish OR nut OR seafood OR "whole grain" OR legumes
#3	#1 AND #2

Supplementary Table 5

Search strategy for WHO International Clinical Trials Registry Platform (ICTRP)

Number	Search terms
#1	mHealth OR "mobile health" OR smartphone OR "mobile app" OR eHealth OR telemedicine OR web-based OR internet-based
#2	diet OR eating OR dietary OR "Body Mass Index" OR BMI OR "body weight" OR vegetable OR fruit OR fish OR nut OR seafood OR "whole grain" OR legumes
#3	#1 AND #2

Supplementary Table 6

Search strategy for University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR)

Search by following terms respectively.

Search terms
mHealth
eHealth
dietary behavior
dietary behaviour
healthy eating

BMJ Open

Comparative effects of behaviour change techniques using eHealth and mHealth in promoting dietary behaviour: protocol for a systematic review and component network meta-analysis

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Manuscript ID	bmjopen-2024-084774.R1
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Primary Subject Heading:	Medical management
Secondary Subject Heading:	Medical education and training
Keywords:	eHealth, Behavior, Meta-Analysis

Comparative effects of behaviour change techniques using eHealth and mHealth in promoting dietary behaviour: protocol for a systematic review and component network meta-analysis

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Keywords: behaviour change techniques, component network meta-analysis, dietary behaviour, eHealth, mHealth

ABSTRACT

Introduction

Globally, it is estimated that dietary habits contribute to 22% of adult deaths and 15% of disability-adjusted life-years, highlighting the critical role of dietary behaviour in public health. Despite the known benefits of healthy eating, many individuals find it challenging to change their diet for disease prevention. eHealth and mHealth interventions using behaviour-change techniques (BCTs) have emerged as promising strategies to address this issue. However, the specific BCTs that are most effective in promoting dietary behaviour are not well established. This systematic review and component network meta-analysis (CNMA) aims to estimate the effect size of each BCT on fostering healthy eating.

Methods and analysis

We will include randomised controlled trials that assess the effects of eHealth and mHealth interventions on promoting changes in dietary behaviours among healthy adults. Studies with a minimum follow-up period of three weeks will be considered. Searches will be conducted in MEDLINE [PubMed], EMBASE [Dialog], Cochrane Central Register of Controlled Trials, PsycInfo [Dialog], ClinicalTrials.gov, the WHO International Clinical Trials Registry Platform, and the University Hospital Medical Information Network Clinical Trials Registry on 27 January 2024. Two independent reviewers will conduct title and abstract screening followed by a full-text review. Disagreements will be resolved through discussion or consultation with a third reviewer. The primary outcome is dietary behaviour, as measured by changes in the diet quality score and the intake of a specific food. Our data synthesis will apply a frequentist random effects model for pairwise meta-analysis, NMA, and an additive CNMA model to compute the effect size of each BCT. This methodological approach will reveal the positive and negative effects of each BCT and provide a ranking of these techniques, considering both direct and indirect evidence.

Ethics and dissemination

Ethical approval is not required for this systematic review because it uses existing published data. These results will be submitted for publication in a peer-reviewed journal. The current protocol was submitted to PROSPERO on 16 January 2024 (CRD 42024502217).

Strengths and limitations of this study

- A systematic approach is used to search, screen, assess, and synthesise the literature, including the prior registration of the protocol in PROSPERO and the evaluation of the risk of bias using Cochrane risk of bias tools.
- The importance of this study is identifying BCT to promote dietary behaviours through CNMA.
- Potential limitations include missing unpublished data.
- As dietary measurements are performed using various methods, a potential limitation of this study is that it is forced to synthesise outcomes using standardised mean differences.

INTRODUCTION

Rationale and Objective

Globally, poor dietary habits have been implicated in approximately 22% of adult deaths and contribute to 15% of disability-adjusted life years [1]. These habits particularly influence the prevalence of cardiovascular disease, which is the leading cause of obesity-exacerbated mortality [2]. Despite the known benefits of healthy eating, individuals often struggle to make substantial and sustained changes to their dietary patterns to reduce disease risk [3].

To address this issue, eHealth and mHealth interventions that leverage technologies such as smartphones and the Internet have been extensively studied in recent decades [4]. Although systematic reviews have evidenced these interventions to be generally effective [5–7], heterogeneity in outcomes suggests a complex interplay of factors that influence their effectiveness.

One factor contributing to this heterogeneity is the complexity of eHealth and mHealth behaviour-change interventions. Each intervention incorporated varying components, resulting in nonconstant effect sizes. In recent years, the determinants of health behaviour have been identified from the perspective of behavioural science and health psychology, and intervention studies aimed at behaviour change have proliferated [8]. Michie et al. systematised and standardised the elements of these behaviour change techniques (BCTs) to be reproducible and not reducible, publishing them in 2013 as the Behaviour Change Technique Taxonomy v1 (BCTTv1), which has gained international consensus [9]. BCTs are categorised into seven cluster solutions and 16 groups and further subdivided into 93 specific techniques. Numerous attempts have been made to enhance eating habits through combined interventions employing BCTs.

However, there is no consensus on the effectiveness of BCTs in promoting dietary behaviour. For example, systematic reviews have indicated that providing feedback, a form of BCT, is effective for behavioural modification [10,11]. Conversely, McDermott et al. contended that the same BCT can produce negative effects [12]. Samdal et al. reviewed the possibility that presenting pros and cons can negatively affect behavioural change using pairwise meta-analysis and meta-regression analysis [13]. Therefore, clarifying the direction and magnitude of the effects of each BCT is crucial, as this will enable the effective design of eHealth and mHealth interventions intended to promote dietary behaviour.

Studies that have assessed the effectiveness of BCTs typically rely on pairwise meta-analyses and meta-regression analyses to elucidate the efficacy of each BCT. However, these approaches have methodological limitations when estimating the effect sizes of individual BCTs. In this study, we will

first verify the effectiveness of eHealth and mHealth interventions in promoting dietary behaviours using pairwise meta-analysis. Subsequently, we will conduct a component network meta-analysis (CNMA) that decomposes interventions into diverse elements to estimate the effect size of each component. This analysis will focus on randomised controlled trials (RCTs) and aim to estimate the effect size of each BCT on dietary behavioural changes with higher reliability using CNMA compared to traditional methods.

METHODS AND ANALYSIS

This systematic review protocol was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P) [14] and PRISMA extension for network meta-analysis [15] and adhered to the Cochrane Handbook for Systematic Reviews of Interventions (Second Edition). The start date of the study was January 2024 and the planned completion date is December 2024.

Eligibility criteria

Studies will be selected according to the criteria outlined below.

Study designs

If applicable, RCTs, including cluster and crossover RCTs, will be included. Quasi-experimental studies will be excluded.

Participants

Healthy adults aged ≥18 years, including overweight or those with obesity but excluding those with specific diseases or conditions, will be included. Adult data will be extracted separately for mixed-population studies.

Interventions

We will consider eHealth and mHealth interventions encompassing electronic health records, telemedicine, mobile health apps, health information portals, and related technologies designed to encourage dietary behaviour. Studies focused on laboratory feeding trials not intended to assess behavioural changes, those promoting prefabricated foods or meal-replacement drinks, and those testing dietary supplements such as fish oil will be excluded from our analysis. Additionally, studies with follow-up data of a minimum of three weeks after randomisation will be included.

Comparators

This study will include a range of comparators, such as different eHealth or mHealth interventions, minimal interventions, usual care, and no interventions.

Outcomes

The primary outcome of this study is the change in dietary behaviours, evaluated through validated scores such as the Healthy Eating Index [16], Mediterranean Diet Score [17], and Dietary Approaches to Stop Hypertension (DASH) score [18], or through the consumption of specific foods recommended in the Mediterranean diet, such as fruits, vegetables, whole grains, nuts, legumes, seafood, and fish.

These changes will be measured using dietary recall, dietary records, dietary history questionnaires, and food frequency questionnaires. Secondary outcomes will be evaluated by integrating the same diet scores or types of food. This study will also examine health-related outcomes, focusing on changes in body weight and body mass index (BMI).

Setting

This study will not be restricted by the type of setting.

Language

Articles reported in any language will be included; however, studies will be searched for in English.

Information sources

The following databases will be searched: MEDLINE [PubMed], EMBASE [Dialog], Cochrane Central Register of Controlled Trials, PsycINFO [Dialog], ClinicalTrials.gov, WHO International Clinical Trials Registry Platform (ICTRP), and University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR). We will search for a full database history from the beginning until 27 January 2024.

Search strategy

The search strategy will employ a combination of controlled terms and free-text words relevant to eHealth/mHealth and dietary behaviour (see Table 1 for the PubMed strategy). Supplementary File 1 contains the full search strategies for the other databases. The search will be performed on 27 January 2024. Before the final analysis, an updated search will ensure the inclusion of the latest studies.

Study records

Data management

Two independent reviewers (TF and NM) will screen the titles and abstracts of the papers identified using the search strategies mentioned earlier. Duplicate papers will be removed using Rayyan [19].

Selection process

If the research title or abstract does not provide sufficient information to determine eligibility, the full paper will be assessed for acceptance or rejection. In case of disagreement between the two reviewers, a senior researcher (TM) will be consulted for the final decision.

Data collection process

- Two independent reviewers (TF and NM) will extract data from eligible studies, excluding BCTs,

in duplicate. The first five titles will be screened in cooperation using a data collection form and discussed by the two reviewers.

- Data related to BCTs will be extracted by TF and checked by NM.
- Disagreements in data extraction will be resolved through discussion, and the study authors will be contacted to clarify uncertainties.

Data items

- A data collection sheet will be prepared, which includes the following:

1. Title/author information
2. Year of publication
3. Study design
4. Eligibility criteria
5. Exclusion criteria
6. Participants' characteristics (demographics, number of endpoints, mean or median age, and sex ratio)
7. Settings
8. Intervention (including comparator) details for each arm (duration, frequency, and BCTs based on BCTTv1, provider, and delivery)
9. Outcome variables for each arm at the longest follow-up (variables and results). If outcomes are assessed at multiple time points, the outcome variables at the shortest follow-up period of more than 3 weeks will also be extracted as secondary data.
10. Methods of dietary assessment
11. Dropout rate

Coding BCTs

The BCT will be coded only when there is clear evidence of inclusion. The 93 BCTs will be coded as present (1) or absent (0). The BCTs of the intervention and control groups will be identified separately. Reviewers will undergo training using the BCT taxonomy v1 online training provided by University College London (https://www.bct-taxonomy.com/?n=1) before the coding. Additionally, if the same studies as those included in this research have been used in previous systematic reviews of BCTs, the coding of BCTs in those reviews will also be referenced.

Outcomes and prioritisation

Primary outcomes

The primary outcome will be dietary and behavioural changes assessed using the validated methods mentioned above. In cases where multiple dietary behaviour outcomes are reported in a single

publication, priority will be given to the primary outcome identified in each article. If no prioritisation of outcomes is provided, preference will be given to composite scores (such as the Healthy Eating Index, Mediterranean Diet Score, and DASH score) over individual food items. For studies reporting multiple time point measurements, we will use the score from the longest available follow-up period to ensure the assessment of sustained dietary behaviour changes for the primary outcome.

Secondary outcomes

The secondary outcomes will assess changes in dietary intake and related health measures, with a particular focus on the following:

1. Daily intake of specific foods (vegetables, fruit, whole grains, nuts, seafood, and fish)
2. Combined daily fruit and vegetable intake
3. Each dietary quality score
4. Body weight (kg)
5. BMI (kg/m²), calculated from height and weight measurements.

If multiple measurements are reported for all secondary outcomes, we will prioritise the data from the longest follow-up period to align with the assessment strategy of the primary outcome.

Additionally, to evaluate the short-term effects of the intervention as secondary outcomes, the primary outcome variables at the shortest follow-up period of more than three weeks extracted from each study will be assessed.

Risk of bias in individual studies

The risk of bias will be assessed independently by two reviewers (TF and NM) using the Cochrane Collaboration tool (RoB 2.0) [20]. Because the study aims to clarify the effect of assignment to an intervention, we will evaluate bias on the effect of assignment to an intervention (the 'intention-to-treat effect') with domain 2 of RoB 2.0. Disagreements will be resolved first by discussion and then by consulting a third author for arbitration.

Data synthesis

Pairwise meta-analysis

We will conduct a pairwise meta-analysis to assess the effectiveness of mHealth and eHealth interventions on each outcome when compared with comparator interventions (e.g., minimal intervention, no intervention, or usual care) when multiple studies containing comparable pairs are identified. Frequentist random-effects models [21] will be used to combine the results. Different scores will be synthesised using SMD, and the same scores will be synthesised using MD with 95%

confidence intervals (CIs). Heterogeneity will be quantified using the Cochrane *Q*-test and the Higgins I^2 statistics.

Network meta-analysis (NMA)

We will perform a random-effects NMA assuming between-study variance across the entire network. We will estimate the summary MD or SMD using the 95% CIs. The surface under the cumulative ranking curve (SUCRA) will be used to assess the relative efficacy of interventions. We will assess the overall evidence for head-to-head comparisons of interventions using network plots [15]. In addition, we will perform statistical evaluations of incoherence in networks using global and local approaches. For the global approach, we will use a design-by-treatment interaction model to assess incoherence [22]. For the local approach, the Bucher local inconsistency test will be used to quantify the incoherence of all triangular loops in the network [23]. We will use the "NMA" package with an R statistical environment [24].

Component network meta-analysis (CNMA)

We will conduct a CNMA to assess the collective effectiveness of the various BCTs. Additive CNMA will be performed under the assumption that the effects of combined treatments can be represented as the sum of their individual components [25]. This model will be particularly useful for isolating the effects of a single BCT when it is part of a combined intervention. The ranking of the BCTs will be estimated using P-scores [26]. The R statistical environment using the "netmeta" package [27] will support the CNMA. Discrepancies between the model-estimated effects and the observed data will be used to evaluate heterogeneity within the CNMA framework [28,29].

Narrative Synthesis

If quantitative synthesis is not feasible owing to between-study heterogeneity or an insufficient number of studies, we will conduct a systematic narrative synthesis. This method will use information from the text and tables to summarise and describe the characteristics and findings of the incorporated studies.

Additional analysis

Subgroup analysis

For a more nuanced understanding of the effectiveness of the interventions, we will perform subgroup analyses within the meta-analysis for the primary outcome if a sufficient number of studies are involved. The factors considered for subgroup analyses will be the participant's health status, with groups divided by mean subject BMI thresholds (≥ 30 or < 30), age categories (≥60 or <60 years), and intervention duration (≥3 or <3 months). Additionally, dietary assessment methods and the specific

provider of the intervention will also be criteria for subgroup analysis. This approach aims to discern differential effects across various populations and intervention contexts.

Sensitivity analysis

Sensitivity analyses will be performed to ascertain the stability of the findings. Priority will be given to eliminating studies with a high risk of bias. Further sensitivity assessments will review the robustness of the results across different levels of BCT classification (7, 16, or 93 categories), ensuring that the analysis accounts for the complexity and specificity of behavioural interventions.

Small study effects

To investigate reporting bias, we will examine studies with RCT protocols that meet the eligibility criteria but have not published their results. ClinicalTrials.gov, ICTRP, and UMIN-CTR will be screened for relevant information. Comparison-adjusted funnel plots and the Egger test will be used to assess potential publication and small study biases.

Confidence in the cumulative estimate

The overall certainty of evidence will be evaluated using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) framework for pairwise meta-analysis. For NMA, the Confidence in Network Meta-Analysis (CINeMA) approach will be considered [30–32].

Ethics and dissemination

Ethics approval is not required because this systematic review will solely use the existing published data. The results will be submitted for publication in a peer-reviewed journal. Any significant protocol changes will be duly documented, providing a description of the change, its rationale, and the date of the amendment, all of which will be included in the final report.

Patient and public involvement

None

Discussion

In this systematic review, we rigorously estimate the effect size of each BCT on dietary behaviour. Notably, no systematic review has explicitly addressed this objective, despite numerous publications focusing on BCTs for dietary behaviours. A critical aspect of this research lies in addressing the challenges inherent in deconstructing and comparatively analysing individual components within complex interventions. This is achieved by employing frequentist CNMA, a methodology that enables feasible and effective comparative analyses.

Given that rising healthcare costs are a major global problem, it is important to reduce healthcare costs by preventing disease. Deterioration of dietary behaviours has been widely reported as a risk factor for various diseases [33,34]. eHealth and mHealth are powerful tools to promote prevention without relying on human resources [35]. However, improving these habits remains a formidable challenge in disease prevention. In this study, estimating the individual effects of BCTs is vital for designing effective strategies to foster behavioural changes. In other words, by identifying behavioural change techniques that are effective in changing eating behaviour and those that have the opposite effect, this research can be used in the design and development of eHealth and mHealth in the future. This approach not only contributes to the academic understanding of BCTs but also has significant practical implications for public health interventions.

The heterogeneity among the studies, particularly in the variety of dietary assessment methods, represents a potential limitation of this study. Information from each study will be carefully extracted, and, where appropriate, sensitivity analyses will be conducted to thoroughly assess comparability.

Authors' contributions:

TM is the guarantor. TF, NM, and TM drafted the manuscript and contributed to the development of the selection criteria, risk of bias assessment strategy, data extraction criteria, and search strategy. HN provided statistical expertise. All authors have read, provided feedback, and approved the final manuscript.

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Competing interests statement:

None declared.

Data availability statement

No datasets were generated and analyzed for this study protocol. No data are available.

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Table 1 Search strategy for PubMed

Number	Search terms
#1	"mHealth"[Title/Abstract] OR ("mobile"[Title/Abstract] AND ("health"[Title/Abstract] OR "application"[Title/Abstract] OR "app"[Title/Abstract] OR "intervention"[Title/Abstract] OR "technology"[Title/Abstract] OR "phone"[Title/Abstract] OR "device*"[Title/Abstract])) OR "smartphone"[Title/Abstract] OR "smart phone"[Title/Abstract] OR "telemedicine"[MeSH Terms] OR "eHealth"[Title/Abstract] OR "SMS"[Title/Abstract] OR "iPod"[Title/Abstract] OR "iPad"[Title/Abstract] OR ("tablet"[Title/Abstract] AND ("device*"[Title/Abstract] OR "machine*" [Title/Abstract] OR "base*" [Title/Abstract] OR "computer*"[Title/Abstract])) OR "CD-ROM"[Title/Abstract] OR "multimedia"[Title/Abstract] OR "e-health"[Title/Abstract] OR "m-health"[Title/Abstract] OR "telemedicine"[Title/Abstract] OR (("digital"[Title/Abstract] OR "internet"[Title/Abstract]) AND ("intervention"[Title/Abstract] OR "base*"[Title/Abstract] OR "delivered"[Title/Abstract])) OR "web-base*"[Title/Abstract]
#2	"diet"[Title/Abstract] OR "dietary"[Title/Abstract] OR "eating"[Title/Abstract] OR "fruit*"[Title/Abstract] OR "vegetable*"[Title/Abstract] OR "BMI"[Title/Abstract] OR "Body Mass Index"[Title/Abstract] OR "body weight"[Title/Abstract] OR "health behavior change*"[Title/Abstract] OR "health behaviour change*"[Title/Abstract] OR "Body Mass Index"[MeSH Terms] OR "vegetables"[MeSH Terms] OR "fruit"[MeSH Terms] OR "diet"[Mesh Terms] OR "food*"[Title/Abstract] OR "food"[Mesh Terms] OR "Seafood"[Mesh Terms] OR "seafood" [Title/Abstract] OR "fish" [Title/Abstract] OR "Whole Grains"[Mesh Terms] OR "whole grain*"[Title/Abstract] OR "Nuts"[Mesh Terms] OR "legumes" [Title/Abstract] OR "Fabaceae"[Mesh Terms]
#3	("randomized controlled trial"[Publication Type] OR "controlled clinical trial"[Publication Type] OR "randomized"[Title/Abstract] OR "randomly"[Title/Abstract] OR "trial"[Title/Abstract] OR "groups"[Title/Abstract]) NOT ("animals"[MeSH Terms] NOT "humans"[MeSH Terms])
#4	#1 AND #2 AND #3

Supplementary Table 1

Search strategy for EMBASE

Number	Search terms
#1	TI("mHealth") OR AB("mHealth") OR TI("mobile health") OR AB("mobile health") OR TI("smartphone") OR AB("smartphone") OR TI("mobile application") OR AB("mobile application") OR TI("mobile app") OR AB("mobile app") OR TI("mobile intervention") OR AB("mobile intervention") OR TI("mobile technology") OR AB("mobile technology") OR TI("mobile phone") OR AB("mobile phone") OR TI("mobile device") OR AB("mobile device") OR TI("telemedicine") OR AB("telemedicine") OR TI("eHealth") OR AB("eHealth") OR TI("SMS") OR AB("SMS") OR TI("iPod") OR AB("iPod") OR TI("iPad") OR AB("iPad") OR TI("CD-ROM") OR AB("CD-ROM") OR TI("multimedia") OR AB("multimedia") OR TI("e-health") OR AB("e-health") OR TI("m-health") OR AB("m-health") OR (TI("tablet") OR AB("tablet")) AND ((TI("device*") OR AB("device*")) OR (TI("machine*") OR AB("machine*")) OR (TI("base*") OR AB("base*")) OR (TI("computer*") OR AB("computer*"))) OR TI("telemedicine") OR AB("telemedicine") OR ((TI("digital") OR AB("digital")) OR (TI("internet") OR AB("internet"))) AND ((TI("intervention") OR AB("intervention")) OR (TI("base*") OR AB("base*")) OR (TI("delivered") OR AB("delivered"))) OR TI("web-base*") OR AB("web-base*") OR EMB("telemedicine") OR EMB("mobile health") OR EMB("electronic health")
#2	TI("diet") OR AB("diet") OR TI("dietary") OR AB("dietary") OR TI("eating") OR AB("eating") OR TI("fruit*") OR AB("fruit*") OR TI("vegetable*") OR AB("vegetable*") OR TI("BMI") OR AB("BMI") OR TI("Body Mass Index") OR AB("Body Mass Index") OR TI("body weight") OR AB("body weight") OR TI("health behavior change*") OR AB("health behavior change*") OR TI("health behaviour change*") OR AB("health behaviour change*") OR TI("food*") OR AB("food*") OR TI("seafood") OR AB("seafood") OR TI("fish") OR AB("fish") OR TI("Whole Grains") OR AB("Whole Grains") OR TI("nuts") OR AB("nuts") OR TI("legumes") OR AB("legumes") OR EMB("diet") OR EMB("vegetables") OR EMB("fruit") OR EMB("food")
#3	EMB.EXPLODE('randomized controlled trial')
#4	EMB('controlled clinical trial')
#5	TI(random*) OR AB(random*) OR OTI(random*)
#6	EMB('randomization')
#7	EMB('intermethod comparison')

#8	TI(placebo) OR AB(placebo) OR OTI(placebo)
#9	TI(compare) OR OTI(compare) OR TI(compared) OR OTI(compared) OR TI(comparison) OR OTI(comparison)
#10	((AB(evaluated) OR AB(evaluate) OR AB(evaluating) OR AB(assessed) OR AB(assess)) AND (AB(compare) OR AB(compared) OR AB(comparing) OR AB(comparison)))
#11	TI(open PRE/1 label) OR AB(open PRE/1 label) OR OTI(open PRE/1 label)
#12	TI((double OR single OR doubly OR singly) PRE/1 (blind OR blinded OR blindly)) OR AB((double OR single OR doubly OR singly) PRE/1 (blind OR blinded OR blindly)) OR OTI((double OR single OR doubly OR singly) PRE/1 (blind OR blinded OR blindly))
#13	EMB('double blind procedure')
#14	TI(parallel PRE/1 group*) OR AB(parallel PRE/1 group*) OR OTI(parallel PRE/1 group*)
#15	(TI(crossover) OR AB(crossover) OR OTI(crossover)) OR (TI('cross over') OR AB('cross over') OR OTI('cross over'))
#16	TI((assign* OR match OR matched OR allocation) NEAR/6 (alternate OR group OR groups OR intervention OR interventions OR patient OR patients OR subject OR subjects OR participant OR participants)) OR AB((assign* OR match OR matched OR allocation) NEAR/6 (alternate OR group OR groups OR intervention OR interventions OR patient OR patients OR subject OR subjects OR participant OR participants)) OR OTI((assign* OR match OR matched OR allocation) NEAR/6 (alternate OR group OR groups OR intervention OR interventions OR patient OR patients OR subject OR subjects OR participant OR participants))
#17	(TI(assigned) OR AB(assigned) OR OTI(assigned)) OR (TI(allocated) OR AB(allocated) OR OTI(allocated))
#18	TI(controlled NEAR/8 (study OR design OR trial)) OR AB(controlled NEAR/8 (study OR design OR trial)) OR OTI(controlled NEAR/8 (study OR design OR trial))
#19	(TI(volunteer) OR AB(volunteer) OR OTI(volunteer)) OR (TI(volunteers) OR AB(volunteers) OR OTI(volunteers))
#20	EMB('human experiment')
#21	TI(trial) OR OTI(trial)
#22	#3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21

#23	(TI(random* PRE/1 sampl* NEAR/8 ("cross section*" OR questionnaire* OR survey OR surveys OR database OR databases)) OR AB(random* PRE/1 sampl* NEAR/8 ("cross section*" OR questionnaire* OR survey OR surveys OR database OR databases)) OR OTI(random* PRE/1 sampl* NEAR/8 ("cross section*" OR "questionnaire*" OR survey OR surveys OR database OR databases))) NOT (EMB('comparative study') OR EMB('controlled study') OR TI('randomised controlled') OR AB('randomised controlled') OR OTI('randomised controlled') OR TI('randomized controlled') OR AB('randomized controlled') OR OTI('randomized controlled') OR TI('randomly assigned') OR AB('randomly assigned') OR OTI('randomly assigned'))
#24	(EMB('cross-sectional study') NOT (EMB.EXPLODE('randomized controlled trial') OR EMB('controlled clinical study') OR EMB('controlled study') OR TI('randomised controlled') OR AB('randomised controlled') OR OTI('randomised controlled') OR TI('randomized controlled') OR AB('randomized controlled') OR OTI('randomized controlled') OR TI('control group') OR AB('control group') OR OTI('control group') OR TI('control groups') OR AB('control groups') OR OTI('control groups')))
#25	((TI('case control*') OR AB('case control*') OR OTI('case control*')) AND (TI('random*') OR AB('random*') OR OTI('random*')) NOT (TI('randomised controlled') OR AB('randomised controlled') OR OTI('randomised controlled') OR TI('randomized controlled') OR AB('randomized controlled') OR OTI('randomized controlled')))
#26	((TI('systematic review') OR OTI('systematic review')) NOT (TI(trial) OR OTI(trial) OR TI(study) OR OTI(study)))
#27	(TI(nonrandom*) OR AB(nonrandom*) OR OTI(nonrandom*)) NOT (TI(random*) OR AB(random*) OR OTI(random*))
#28	TI('random field*') OR AB('random field*') OR OTI('random field*')
#29	TI('random cluster' NEAR/4 sampl*) OR AB('random cluster' NEAR/4 sampl*) OR OTI('random cluster' NEAR/4 sampl*)
#30	(AB(review) AND RTYPE(review)) NOT (TI(trial) OR OTI(trial))
#31	(AB('we searched') AND (TI(review) OR OTI(review) OR RTYPE(review)))
#32	AB('update review')
#33	AB(databases NEAR/5 searched)

#34	(TI(rat) OR OTI(rat) OR TI(rats) OR OTI(rats) OR TI(mouse) OR OTI(mouse) OR TI(mice) OR OTI(mice) OR TI(swine) OR OTI(swine) OR TI(porcine) OR OTI(porcine) OR TI(murine) OR OTI(murine) OR TI(sheep) OR OTI(sheep) OR TI(lambs) OR OTI(lambs) OR TI(pigs) OR OTI(pigs) OR TI(piglets) OR OTI(piglets) OR TI(rabbit) OR OTI(rabbit) OR TI(rabbits) OR OTI(rabbits) OR TI(cat) OR OTI(cat) OR TI(cats) OR OTI(cats) OR TI(dog) OR OTI(dog) OR TI(dogs) OR OTI(dogs) OR TI(cattle) OR OTI(cattle) OR TI(bovine) OR OTI(bovine) OR TI(monkey) OR OTI(monkey) OR TI(monkeys) OR OTI(monkeys) OR TI(trout) OR OTI(trout) OR TI(marmoset*) OR OTI(marmoset*)) AND EMB('animal experiment')
#35	(EMB('animal experiment') NOT (EMB('human experiment') OR EMB('human')))
#36	#23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35
#37	#22 NOT #36
#38	#1 AND #2 AND #37

Supplementary Table 2

Search strategy for the Cochrane Central Register of Controlled Trials

Number	Search terms
#1	MeSH descriptor: [Telemedicine] explode all trees
#2	“ mHealth”:ti,ab OR “mobile health”:ti,ab OR “smartphone”:ti,ab OR “smart phone”:ti,ab OR “mobile application”:ti,ab OR mobile NEXT app*:ti,ab OR “mobile intervention”:ti,ab OR “mobile technology”:ti,ab OR “mobile technologies”:ti,ab OR “mobile phone”:ti,ab OR “mobile device”:ti,ab OR “telemedicine”:ti,ab OR “eHealth”:ti,ab OR “SMS”:ti,ab OR “iPod”:ti,ab OR “iPad”:ti,ab OR “CD-ROM”:ti,ab OR “multimedia”:ti,ab OR “e-health”:ti OR “m-health”:ti,ab OR (“tablet” NEXT (device*:ti,ab OR machine*:ti,ab OR base:ti,ab OR based:ti,ab OR computer*:ti,ab)) OR ((“digital”:ti,ab OR “internet”:ti,ab) AND (“intervention”:ti,ab OR “base*”:ti,ab OR “delivered”:ti,ab))
#3	MeSH descriptor: [Vegetables] explode all trees
#4	MeSH descriptor: [Fruit] explode all trees
#5	MeSH descriptor: [Food] explode all trees
#6	MeSH descriptor: [Diet] explode all trees
#7	Diet*:ti,ab OR “dietary”:ti,ab OR “eating”:ti,ab OR fruit*:ti,ab OR vegetable*:ti,ab OR “BMI”:ti,ab OR “Body Mass Index”:ti,ab OR “body weight”:ti,ab OR health NEXT behavior NEXT change*:ti,ab OR health NEXT behaviour NEXT change*:ti,ab OR food*:ti,ab OR “seafood”:ti,ab OR “fish”:ti,ab OR whole NEXT

	grain*:ti,ab OR Nut*:ti,ab OR "legumes":ti,ab
#8	(#1 OR #2) AND (#3 OR #4 OR #5 OR #6 OR #7)

Supplementary Table 3

Search strategy for PsycINFO

Number	Search terms
#1	"mHealth" OR "mobile health" OR "smartphone" OR "smart phone" OR "mobile application" OR "mobile app" OR "mobile intervention" OR "mobile technology" OR "mobile technologies" OR "mobile phone" OR "mobile device" OR "telemedicine" OR "eHealth" OR "SMS" OR "iPod" OR "iPad" OR "CD-ROM" OR "multimedia" OR "e-health" OR "m-health" OR ("tablet" AND ("device*" OR "machine*" OR "base*" OR "computer*")) OR "telemedicine" OR (("digital" OR "internet") AND ("intervention" OR "base*" OR "delivered")) OR "web-base*" OR SU.EXACT("Telemedicine")
#2	"diet" OR "dietary" OR "eating" OR "fruit*" OR "vegetable*" OR "BMI" OR "Body Mass Index" OR "body weight" OR "health behavior change*" OR "health behaviour change*" OR "food*" OR "Seafood" OR "seafood" OR "fish" OR "whole grain*" OR "Nut*" OR "legumes" OR SU.EXACT("Diets") OR SU.EXACT("Food")
#3	SU.EXACT("Treatment Effectiveness Evaluation") OR SU.EXACT.EXPLODE("Treatment Outcomes") OR SU.EXACT("Placebo") OR SU.EXACT("Followup Studies") OR placebo* OR random* OR "comparative stud*" OR clinical NEAR/3 trial* OR research NEAR/3 design OR evaluat* NEAR/3 stud* OR prospectiv* NEAR/3 stud* OR (singl* OR doubl* OR trebl* OR tripl*) NEAR/3 (blind* OR mask*)
#4	#1 AND #2 AND #3

Supplementary Table 4

Search strategy for Clinicaltrials.gov

Number	Search terms
#1	mHealth OR "mobile health" OR smartphone OR "mobile app" OR eHealth OR telemedicine OR web-based OR internet-based
#2	diet OR eating OR dietary OR "Body Mass Index" OR BMI OR "body weight" OR vegetable OR fruit OR fish OR nut OR seafood OR "whole grain" OR legumes
#3	#1 AND #2

Supplementary Table 5

Search strategy for WHO International Clinical Trials Registry Platform (ICTRP)

Number	Search terms
#1	mHealth OR "mobile health" OR smartphone OR "mobile app" OR eHealth OR telemedicine OR web-based OR internet-based
#2	diet OR eating OR dietary OR "Body Mass Index" OR BMI OR "body weight" OR vegetable OR fruit OR fish OR nut OR seafood OR "whole grain" OR legumes
#3	#1 AND #2

Supplementary Table 6

Search strategy for University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR)

Search by following terms respectively.

Search terms
mHealth
eHealth
dietary behavior
dietary behaviour
healthy eating