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Abstract

Background: The use of digitally-enabled care and the emphasis on self-management of health is growing. Mobile health apps provide a promising means of supporting health behaviour change; however, engagement with them is often poor and evidence of their impact on health outcomes is lacking. As engagement is a key prerequisite to health behaviour change, it is essential to understand how engagement with mobile health apps and their target health behaviours can be better supported. Despite an increasing recognition of the importance of engagement in the literature, there is still a lack of understanding of how different components of engagement are associated with specific techniques that aim to change behaviours.

Objective: The purpose of this systematic review protocol is to provide a synthesis of the associations between various Behaviour Change Techniques (BCTs) and the different components of engagement (and their outcome measures) with mobile health apps.

Methods: The review protocol was structured using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) and the Population, Intervention, Comparator, and Outcome (PICO) frameworks. Seven databases will be systematically searched: PubMed, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), APA PsycInfo, ScienceDirect, Cochrane Library and Web of Science. Title and abstract screening, full-text review, and data extraction will be conducted by two independent reviewers. Data will be extracted into a predetermined form, and any disagreements in screening or data extraction will be discussed, with a third reviewer consulted if consensus cannot be reached. Risk of bias will be assessed using the Cochrane Collaboration Risk of Bias 2 and ROBINS-I tools and descriptive and thematic analyses will be used to summarise the relationships between BCTs and the different components of engagement.

Results: The systematic review has not been started. It is expected to be completed and submitted for publication by April 2022.

Conclusions: This systematic review will summarize the associations between different BCTs and various components and measures of engagement with mobile health apps. This will identify areas where further research is needed to examine BCTs that could potentially support effective engagement and help to inform the design and evaluation of future mobile health apps.

Trial Registration: PROSPERO (reference number TBD)

Keywords

Introduction

Background

This systematic review aims to provide an overview of how Behaviour Change Techniques (BCTs) [1] are associated with different components of engagement with mobile health apps. Effective engagement with digital health interventions is an essential factor in their ability to support positive behaviour change; however, although several models and frameworks conceptualising engagement and its association with intervention impact have recently been published, a comprehensive understanding of how to develop digital health interventions that significantly impact health behaviour and outcomes is still lacking [2]. This is a serious concern because while mobile health apps are frequently used to deliver health behaviour change interventions [3], there is still a lack of evidence supporting their impact on behaviour and health outcomes [4,5]. This lack of evidence necessitates an in-depth examination of the stages of engagement and behaviour change, so that particular barriers and blockers can be targeted. BCTs, "observable, replicable, and irreducible component[s]" of behaviour change interventions [1], provide a means of reliably classifying and testing potential strategies of altering behaviour to address particular barriers. Understanding the associations between different BCTs, theoretical components of engagement, and measures of engagement will provide insight into how BCTs can be incorporated to improve and personalise the design of digital health interventions to support effective engagement.

Engagement with digital health interventions can be poor and limits their potential impact. As healthcare service delivery becomes increasingly digital and accessible through personal devices like smartphones and wearables [6,7], there is a need to ensure that these digital interventions are achieving their intended outcomes. The potential impact of digital interventions is limited by the extent of users' engagement with them [8–10]; a meta-analysis of engagement with digital mental health interventions found a significant positive association between engagement and mental health outcomes [11]. However, the variety in definitions and measures of engagement means that reliable quantitative estimates of the relationship between engagement and outcomes are still lacking [8,11]. Maintaining engagement with digital health interventions is a common challenge. Studies of engagement with mobile health apps and wearable devices often observe poor long-term use [12–14] and high rates of attrition [15,16]. Although duration of use is a commonly-used indicator of engagement with a digital health intervention, its validity has been questioned because it only captures one component of engagement [2,10].

Inconsistency in the way engagement is defined and measured is one of the challenges with studying engagement [17,18]. The lack of a clear, comprehensive, and well-accepted conceptualisation of engagement was a major gap, which several papers and reviews have recently tried to address [2,17,19,20]. Although various models and definitions of engagement have been proposed [17], there is a general consensus that engagement is a multi-faceted concept [17–19,21,22]. These conceptual frameworks highlight the importance of considering cognitive, behavioural, and affective aspects of engagement [10,17,19,22], as well as examining different levels of engagement with digital behaviour change interventions (DBCIs) - with the digital intervention and with the health behaviour [18,21] (see Figure 1). One key review defined engagement in terms of two key components: extent of usage and subjective experience [19]. Another paper emphasises the importance of the relationship between engagement with the intervention and the target behaviour by defining 'effective engagement' as the level of engagement sufficient to achieve the aims of the intervention [23]. This highlights the crucial distinction between engagement with the intervention and

engagement with the behaviour, as frequent or indefinite engagement with the intervention may not be required to support sustained engagement with the behaviour (see Figure 1).
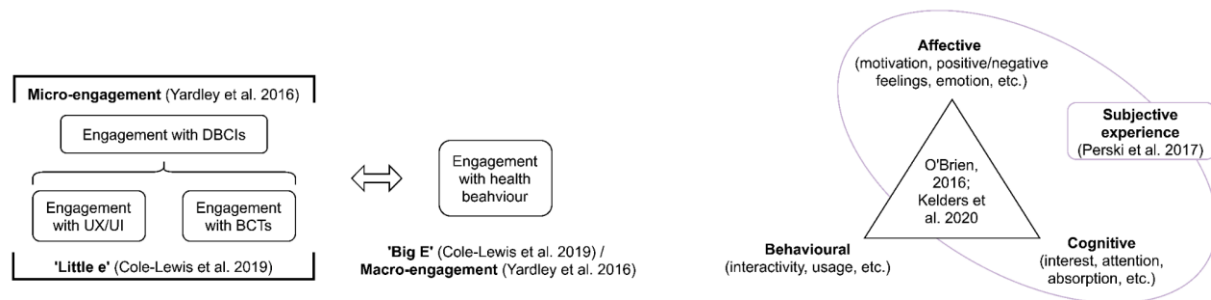

Figure 1. Summary of key theoretical concepts of engagement with digital health (based on [17–19,22,23])

Engagement with the intervention can be subdivided into engagement with the device or software and engagement with BCTs or 'active ingredients' of the intervention [18,24] (see Figure 1, far left). As the DBCI is the proposed trigger for the behaviour change, engagement with the health behaviour is thought to depend on engagement with the DBCI [18,23]. However, the interconnected nature of engagement with the device, the BCTs, and the behaviour makes it challenging to untangle the relationships between various stages and components of engagement and different BCTs. This is because BCTs can be used to influence users' engagement with the health behaviour; for example, by including goal setting (BCT 1.1) or self-monitoring of behaviour (BCT 2.3) features to support users' engagement with physical activity. But BCTs can also 'feed back' to influence engagement with device or with other BCTs included in the DBCI; for example, using prompts or cues (BCT 7.1) such as app notifications to remind a user to engage with the app and/or specific BCT-based features on the app.

Different BCTs are associated with different theoretical barriers to behaviour (e.g. capability, opportunity, and motivation [25,26]). For instance, BCT 4.1 'instruction on how to perform the behaviour' is commonly used to support a 'training' intervention function, which in turn can target barriers related to physical and psychological capability [26]. Give the different functions associated with BCTs, it seems likely that different BCTs will also have different relationships with the three main components of engagement (affective, cognitive, and behavioural). To improve engagement with DBCIs - and hopefully target behaviours and health outcomes - it is essential the relationships between BCTs and the various components of engagement are understood and incorporated into the design and evaluation of digital health interventions.

Rationale

The growing recognition of the importance of engagement in the design and evaluation of digital health interventions has resulted in a recent exponential increase in research concerning that topic. Given the accepted importance of engagement as a prerequisite for behaviour change [19], several systematic reviews have examined various factors that could influence engagement with digital health interventions [27–30]. One of these reviews [27] structured their analysis around the Capability, Opportunity, Motivation - Behaviour (COM-B) model, which is part of the Behaviour Change Wheel theoretical framework [25]. The authors identified 26 different factors relating to capability, opportunity, and motivation that

have been associated with uptake of and engagement with mobile health apps in the literature [27]. This provides a valuable, theory-based contribution to the understanding of factors affecting engagement with mobile health apps. However, although the review included studies with either qualitative and quantitative (primarily system use data) measures of engagement and used a multi-faceted definition of engagement [19], there was no consideration of how the influence of these factors varied for the different components and measures of engagement.

The value in understanding the factors associated with engagement is in their potential to inform design that improves 'effective engagement' with DBCIs and thereby better supports behaviour change and associated positive health outcomes. Because engagement is a complex and multi-faceted concept, it is important to understand how specific BCTs are related to different elements of engagement, and which have the most influence on 'effective engagement' and health outcomes [23]. As the best strategies for achieving effective engagement could differ among individuals, an understanding of how different BCTs are associated with different components of engagement would enable digital health interventions to be personalised to individuals or specific populations or contexts, providing an opportunity to increase their health impact.

PROSPERO was searched using various combinations of the keywords 'engagement', 'digital health interventions', 'digital behaviour change interventions', 'behaviour change techniques', 'BCT', 'mobile health apps', 'mHealth', 'eHealth', and 'digital behaviour change'. None of the registered protocols aimed to examine the associations between BCTs and the different components of engagement; however, the search terms identified the PROSPERO pre-registration for one of the previous reviews cited in this rationale [27], indicating that the search terms were appropriate.

Objectives

The main aim of the review is to provide a synthesis of the associations between Behaviour Change Techniques and the different components of engagement (and their outcome measures) with mobile health apps in the literature. To achieve this aim, there will be four key objectives:

1. To identify the BCTs being incorporated in the development of mobile health apps;
2. To identify the components of engagement that are being evaluated in studies of mobile health apps and how the different components are being measured;
3. To document the associations between specific BCTs and engagement component outcomes and outcome measures;
4. To compare those associations across the included studies to hypothesise causal relationships between specific BCTs and specific components of engagement that can be empirically evaluated in future studies.

Methods

Overview

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) framework [31] and the population, intervention, comparator, outcome, and studies framework [32,33] will be used to structure this review and develop the search strategy. This review will be prospectively registered on PROSPERO (reference # TBD).

Eligibility criteria

The population, intervention, comparator, outcome, and study type framework (Table 1) is based on the research questions.

Table 1. PICOS framework

Population	Mobile health app users of any age (adults and children)
Intervention	Mobile health apps that explicitly use BCTs in their design to target at least one of five key health categories established in the literature: drug use, alcohol use, diet, physical activity, and mental health.
Comparator	No comparator is required.
Outcomes	The primary outcome will be the qualitative or quantitative engagement outcomes measured (including any components of engagement specified by a theoretical framework). Secondary outcomes will include the BCTs included in the mobile health app, the measure(s) of engagement used by the study, and the behavioural and health outcomes reported.
Study types	Studies that evaluate engagement with at least one mobile health app that uses BCTs will be eligible (including randomized controlled trials, quantitative, qualitative, cohort, and case studies). Reviews, protocols, and papers that describe interventions without evaluating them will be excluded.

Search strategy

The search will be conducted in seven databases: PubMed, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), APA PsycInfo, ScienceDirect, Cochrane Library, and Web of Science. These databases were chosen because they were commonly searched in previous systematic reviews relating to engagement and digital health interventions and have broad coverage of digital technology, health, and behavioural fields of literature. Keywords and MeSH terms relating to engagement with digital health behaviour change interventions were identified in an initial review of the literature and used to develop the search strategy. These search terms were expanded upon and grouped into three themes (see Table 2) to develop the following search structure: engagement (MeSH OR Keywords) AND mobile health apps (MeSH OR Keywords) AND behaviour change (MeSH OR Keywords). Sample searches conducted in PubMed, Embase (Ovid), and Web of Science are included in Appendix 1.

Table 2. Search terms

Category	MeSH	Keywords (in title or abstract)

Engagement	Treatment Adherence and Compliance OR Patient Participation OR Patient Compliance	Engagement OR adherence OR compliance OR maintenance OR acceptability OR satisfaction OR attention OR enjoyment OR interest OR affect OR flow OR "cognitive absorption" OR "subjective experience" OR immersion OR presence OR ((amount OR frequency OR duration OR depth OR breadth) NEAR/2 (use OR usage)) OR dose OR stickiness OR dropout OR "drop out" OR "drop-out" OR attrition
Mobile health apps	Telemedicine OR Mobile Applications	"mHealth" OR "mobile health" OR "eHealth" OR telehealth OR ((mobile OR phone OR smartphone OR cell OR mHealth OR "behaviour change" OR "behavior change" OR digital) NEAR/2 (app OR apps OR application*))
Behaviour change	Behavior Control	"behaviour change techniques" or "behavior change techniques" or "BCT" or "behaviour change technique" or "behavior change technique" or "behavioral change strategies" or "behavioural change strategies" or "behaviour change wheel" or "behavior change wheel" or "behavioural theory" or "behavioral theory" or "behaviour change theory" or "behavior change theory" or "health behaviour change" or "behaviour change" or "behavior change" or "digital behaviour change intervention" or "digital behavior change intervention" or "DBCI" or "behaviour change intervention"

Inclusion criteria

The review will include studies that evaluate theory-based, mobile applications for health behaviour change. Any study will be included if they evaluate at least one component or measure of engagement (quantitative or qualitative) with a mobile app that uses Behaviour Change Techniques to influence health behaviour. No restrictions will be placed on the type of health behaviour or the sample population examined in the initial screening, to ensure that all eligible studies are identified. If there are too many studies eligible after initial screening to feasibly review, the included studies will be restricted based on health behaviour. This will limit included studies to those that focus on at least one of five key health categories: drug use, alcohol use, diet, physical activity, and mental health [34–36]; aligned with a previous review by the authors [5]. Studies with any type of sampled population will be eligible for inclusion, with no restrictions on age, gender, or county. Interventions with comparisons to control groups with no intervention, waiting list or irrelevant interventions, minimal interventions, usual care, other mobile apps, telemedicine, online or in-person interventions will all be included. Studies with no comparator will also be included.

Exclusion criteria

Studies of mobile health apps that do not detail the BCTs included in the app will be excluded from the review. Studies that do not evaluate at least one measure of engagement, such as reviews, protocols, and papers that describe interventions without evaluating them, will also be excluded.

Screening and Article Selection

The references returned by the searches of each database will be exported into the citation management software EndNote X9 so duplicate references can be identified and removed. The screening will take place in three stages: 1) keywords based on the search criteria will be entered into EndNote's search function over multiple passes to exclude any studies that clearly ineligible (e.g. protocols, reviews); 2) the titles and abstracts of the remaining references will be screened by two independent reviewers; and 3) the full texts of the studies will be screened by two independent reviewers to determine the final set of included papers. Any disagreements between reviewers will be discussed until consensus; if consensus cannot be reached, a third reviewer will be consulted. Details of the screening and selection process will be recorded in a PRISMA flow diagram to ensure study reproducibility and the stage 1 EndNote searches will be recorded and included in the review as an appendix.

Data Extraction

The full text of each of the articles included in the final set will be read by two independent reviewers to extract predetermined data (see Table 3). As with the screening, any disagreements will be discussed and resolved by a third reviewer if necessary.

Table 3. Article information and data extraction

Article information	Data to be extracted
General study information	Year of publication
	Country of study
	Sample demographics (including age, gender, target population)
	Initial / intended sample size
	Analysed sample size
	Study duration
Intervention	App name
	Operating platform (e.g. iOS, Android)
	Target health behaviour
	Specific aim of the intervention
	Behavioural theory used in the design of the app (if any)
	How the app was developed (e.g. iterative design, experience-based co-design (EBCD), etc.)
	Number of included Behaviour Change Techniques [1]
	List of included Behaviour Change Techniques [1]

	Intended purpose of included Behaviour Change Techniques [1] (if specified)
	Intended use (e.g. dose, duration; if specified)
Evaluation	Component(s) of engagement examined
	Engagement outcome measures
	Effect of intervention on engagement outcomes (including engagement with specific BCTs, the app, and the target health behaviour)
	Effect of intervention on behaviour change outcomes
	Effect of intervention on participant health outcomes

Quality Appraisal and Risk of Bias Assessment

The risk of bias of the studies will be evaluated by two independent reviewers, using the Cochrane Collaboration Risk of Bias 2 tool for randomised controlled trials (RCTs) [37,38] and the ROBINS-I tool for non-randomised studies [39]. The GRADE guidelines will be used to assess the strength of the body of evidence gathered by the review [40].

Data Analysis and Synthesis

The feasibility of conducting a meta-analysis will be examined when the data has been extracted; however, a meta-analysis may not be possible due to the expected variety of study aims, measures, and reported outcomes. The extracted data will be summarised using a descriptive analysis to provide counts of engagement components examined, outcome measures used, health behaviours targeted, and levels of evidence of effectiveness for engagement, behavioural, and health outcomes. The associations between the inclusion of various BCTs and evidence of effectiveness for various outcomes will be mapped. Any qualitative data reported will be examined using a thematic analysis to provide contextual data about the potential relationships between BCTs and certain components of engagement. The risk of bias in the studies will be considered in the synthesis.

Results

The full systematic review has not yet begun but is expected to be completed and submitted for publication by April 2022.

Discussion

A systematic review of the literature on engagement with theoretically-based mobile apps for health behaviour change will contribute to the understanding of how BCTs fit into the multi-faceted state and process of engagement. With the ubiquity of mobile health apps and the continued growth of digitally-enabled care [41], there is a need to ensure that the mobile health apps being used are effective. A key component of the efficacy of digital behaviour change interventions is the extent to which the user engages effectively with the intervention to achieve the intended target behaviour. An overview of the associations between BCTs and

the different components and measures of engagement will inform the design and evaluation of mobile health apps. Based on the data, this section will explore what conclusions can be drawn, the limitations of the systematic review, and key topics for future research.

Author Contributions

The protocol was conceived and written by MMI with revisions from EM, SH, and JA.

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