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Review Paper

How do mobile health applications support behaviour changes? A scoping review of mobile health applications relating to physical activity and eating behaviours

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ABSTRACT

Objective: The objective of this review was to analyse how researchers conducting studies about mobile health applications (MHApps) effectiveness assess the conditions of this effectiveness.
Study design: A scoping review according to PRIMSA-ScR checklist.
Methods: We conducted a scoping review of efficacy/effectiveness conditions in high internal validity studies assessing the efficacy of MHApps in changing physical activity behaviours and eating habits. We used the PubMed, Web of Science, SPORTDiscus and PsycINFO databases and processed the review according to the O'Malley and PRISMA-ScR recommendations. We selected studies with high internal validity methodologies (randomised controlled trials, quasi-experimental studies, systematic reviews and meta-analyses), dealing with dietary and/or physical activity behaviours; covering primary, secondary or tertiary prevention and dealing with behaviour change (uptake, maintenance). We excluded articles on MHApps relating to high-level sport and telemedicine. The process for selecting studies followed a set protocol with two authors who independently appraised the studies.
Results: Twenty-two articles were finally selected and analysed. We noted that the mechanisms and techniques to support behaviour changes were poorly reported and studied. There was no explanation of how these MHApps work and how they could be transferred or not. Indeed, the main efficacy conditions reported by authors refer to practical aspects of

Abbreviations: Apps, Applications; BCT, Behaviour Change technique; MHApps, Mobile Health Applications.

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the tools. Moreover, the issue of social inequalities was essentially reduced to access to the technology (the shrinking access divide), and literacy was poorly studied, even though it is an important consideration in digital prevention. All in all, even when they dealt with behaviours, the evaluations were tool-focused rather than intervention-focused and did not allow a comprehensive assessment of MHApps.

Conclusion: To understand the added value of MHApps in supporting behaviour changes, it seems important to draw on the paradigms relating to health technology assessment considering the characteristics of the technologies and on the evaluation of complex interventions considering the characteristics of prevention. This combined approach may help to clarify how these patient-focused MHApps work and is a condition for improved assessment of MHApps in terms of effectiveness, transferability and scalability.

Introduction

Mobile health applications (MHApps) are becoming a major feature of our daily lives. For instance, according to Statista,[1] in 2019, the number of mobile phone users worldwide is forecast to reach 4.68 billion. According to *Le livre vert de la santé mobile*, half of them use MHApps.[2] The MHApps referred to by Aungst[3] as 'patient-focused' are increasingly used for smoking cessation, changing eating habits and physical exercise.[2,4] These patient-focused MHApps are used for health promotion, communication, health monitoring and reminders for taking medication. They may be associated with connected devices used for automatic data collection.

Although MHApps are now considered as a new mode of prevention,[5] 39% of commercial health apps are thought to be used no more than 10 times before being abandoned.[6] There is no community consensus on their effectiveness, which depends on many factors not reported in studies.[7] Indeed, numerous works have addressed the factors of effective health behaviour changes in MHApps,[8] but Petit and Cambon have shown that these factors are barely reported in evaluation studies.[9] For instance, a comparative descriptive assessment of the top-rated free apps in the health and fitness category available in the Apple Store® shows that few apps in this category are theory-based.[10] The same observation can be made about studies on MHApps related to physical activity behaviours.[11] In the same vein, the most popular commercial apps for managing weight have been shown to provide suboptimal quality for fulfilling their purpose.[12] Yet evaluation studies, notably experimental studies offering internal validity, are what inform practitioners and decision-makers in using apps in practice. So the question is: if experimental design is the best way to assess the efficacy/effectiveness of apps in terms of behaviour changes, how should the different factors influencing results be considered to inform practitioners and decision-makers more accurately? In other words, how can effectiveness mechanisms be explored? To answer this question, we conducted a scoping review.[13] The objective of this review is to analyse how researchers conducting studies about MHApps effectiveness assess the conditions of this effectiveness. We decided to focus on the two positive health determinants most commonly addressed by MHApps: eating habits and physical activity.[2] This article presents and discusses the method and the results of this review, highlighting the methodological challenges of assessing prevention MHApps.

Methods

Design

We conducted a scoping review[14] because such reviews 'are exploratory and systematically sift through available literature on a particular subject, identifying key concepts, theories, sources of conclusive evidence and knowledge gaps […]'.[15] It thus suited our purpose. We followed the five stages described by Arksey and O'Malley:[14] (1) identifying the research question; (2) identifying relevant studies; (3) selecting studies; (4) charting the data; and (5) collating, summarising and reporting the results. We also applied the preferred reporting items for systematic reviews and meta-analyses extension for scoping reviews (PRISMA-ScR guideline[16]) (in our study, all of the items are relevant except 10, 11, 12: these data items are outside the scope of our objectives).

Full electronic search strategy

We performed a literature search using the following keywords: BEHAVIOR AND 'NUTRITION OR DIET' AND 'SMART OR EHEALTH OR MHEALTH' AND 'HEALTH PATHWAY OR COACHING OR E-COACHING' AND CARE. The keywords were chosen during a meeting with all the authors. We searched in the PubMed, Web of Science, SPORTDiscus and PsycINFO databases. These databases were chosen because they are multidisciplinary, including human sciences. They fit our research objective of selecting experimental studies.

We searched for all original (referring to original research) and methodological articles indexed between January 2005 and January 2017 in English or in French and selected relevant articles according to the following criteria: assessing the effectiveness of patient-focused smart devices and applications; evaluation with high-internal validity methodologies (randomised controlled trial, quasi-experimental study,

systematic review, meta-analysis); dealing with dietary and/or physical activity behaviours; covering primary, secondary or tertiary prevention; and dealing with behaviour change (uptake, maintenance). We excluded articles on MHApps relating to high-level sport and those dealing with MHApps in telemedicine (tele-expertise). We selected the identified articles on the basis of their abstracts through double reading using the Covidence software.[17] The complete articles were analysed using the NVivo 11 software®.

Data analysis

Our aim was to understand how researchers assess effectiveness conditions in their studies. First, we conducted a description of articles covering eight dimensions defining the scope of assessment of apps: characteristics of the population, state of health of this population, health determinant targeted, design, tools used, activities included in MHApps, level of action and outcomes in terms of behaviour change. Table 1 shows the eight scoping dimensions with subcategories and objects for analysis.

Second, we analysed how the mechanisms of effectiveness were reported. We considered the mechanisms as per Michie's definition.[18] In the articles, we looked more specifically for:

- The behaviour change techniques (BCTs) used, according to the taxonomy by Michie et al.[18] and Cane et al.,[19] defined as 'active ingredients within the intervention designed to change behaviour'.
- The classical psychosocial theories used without prior classification (e.g. social cognitive theory from Bandura,[20] transtheoretical model from Prochaska,[21] etc.).
- All other mechanisms reported by authors.

Table 1 – Description of articles.

Dimensions	Subcategories and objects for analysis
Characteristics of the population using MHApps	Age: • 0–17 years (children- adolescents) • 18–59 years (adults) • + 60 years (older adults) For those articles in which two categories overlapped, even partially, (e.g. 18–70 years), both categories were analysed together
	Sex: • Male • Female • Males + females
	Hardship/financial insecurity This category was included if articles explicitly mentioned low-income populations or those with little access to healthcare services
State of health	• Without illness • Chronic illness • Acute illness
Health determinant targeted	• Physical activity (PA) • Diet (D), PA and D • PA and D and other(s)
Designs	• Randomised control trial • Quasi-experimental study • Meta-analysis • Systematic review
Tools used	• Connected device with an application • Smartphone application without a connected device
Activities	• Coaching by text messaging (SMS, messenger, e-mail), face to face or working group, phone • Web-based exchange, forum • Focus group • Self-help support
Level of action	• Individual • Collective • Social • Environmental • Set-up of healthcare services and policy
Outcomes in terms of behaviour change	• Behaviour change • Maintenance of the new behaviour

MHApps, mobile health applications.

Results

We identified 2585 articles. We removed 604 duplicates, bringing the number of abstracts selected to 1981. After reading the abstracts, we selected 89 complete articles to read. We excluded articles dealing with behaviour coaching without the use of MHApps, ones that did not assess patient-focused applications and ones that did not provide any details, even minimal (participation, adherence), about the behaviour change process assessed. After reading, we finally selected 22 articles for analysis. The flow chart (Fig. 1) shows our selection method. The 22 articles selected were original studies.

Description

The 22 articles were analysed and classified according to the eight dimensions described below. Table 2 presents how the articles were distributed across these dimensions. To summarise, the major part (20 articles) of articles dealt with adult people. 13 articles covered ages over 60 years. Social inequalities and social gradient are only occasionally mentioned in the articles and often reduced to the issue of access to the technology. The other sources of inequalities such as literacy level or cultural access are poorly reported and without an explanation of the mechanisms involved.

In total, 16 articles dealt with primary prevention (no illness), eight articles dealt with tertiary prevention for treating chronic illness and two dealt with both primary and tertiary prevention. In all the articles, programs essentially acted upon behavioural and individual determinants. However, six articles out of 22 mentioned some of social determinants: involvement of friends and families, members of users' communities and the use of social media. Just one article mentioned the environmental determinant without further exploration. Most MHApps combined diet and physical activity and are associated with a third theme: stress. Most articles

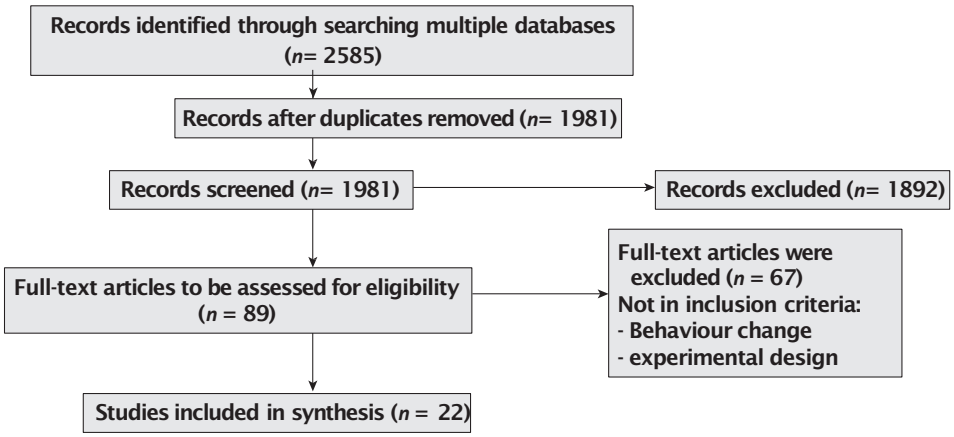

Fig. 1 – Flow chart of article selection process.

dealt with smartphone apps without smart devices, five with connected objects combined with an app. Finally, all articles explored the start of behaviour change. Among them, only five of them dealt with the maintenance of behaviour change, one of them exclusively.

Analysis of effectiveness conditions

Table 3 shows the classification of articles according to focal points addressing the effectiveness conditions described in the Methods section: psychosocial theories and taxonomy of BCTs.

Use of theories or taxonomy to understand mechanisms of efficacy

Twelve articles mentioned the use of a theory.[22–33] In all, six theories were identified: five articles cited Classical learning theories,[34] three articles cited the Transtheoretical model,[35] one article cited Relapse prevention,[36] nine articles cited Social cognitive theory,[20] two articles cited Theory of planned behaviour[37] and one article cited Ecological perspective.[38] However, although these theories were mentioned, the articles did not explain how they are used to build the MHApps. It is interesting to note that the cost of apps does not influence the use of theories.[39] In the same vein, only 15 articles used specific change techniques.[22–26,29–33,40–44] Michie's taxonomy is cited in two articles.[18,19] The four most used BCT categories in these 15 articles are as follows: goals and planning (11 articles), feedback and monitoring (nine articles), shaping knowledge (eight articles) and social support (seven articles). This is consistent with the main uses of MHApps, the quantified self and data sharing.[9]

Though few studies attempted to objectify the mechanisms of efficacy through theories or BCTs, some authors[26,31] pointed out that different mechanisms can be used to improve motivation, especially among young adults: health status, social image or individual factors such as emotions, self-esteem or self-confidence.

Other efficacy conditions

Some authors reported other conditions that may influence results, especially practical conditions: practical use (ergonomics) and communication modes, especially the ability to cater to user needs (as a first-line aid and, over time, the ability to adapt to the needs of users in their environment) and access to the health system (geographic and social). Indeed, the ergonomic factor relates to convenience, with users seeming to prefer uncluttered screens and menus that are easy to browse: rapid, responsive and relevant to user needs and with relevant and timely messages and notifications.[29,31] Adaptability offers users the opportunity to modify the environment.[45]

The type of message is important: users prefer and are more sensitive to messages relating directly to behaviour such as short daily or weekly feedback messages,[29] motivational messages, incentives for self-monitoring or progress reports,[43] tips and hints.[29] Messages containing general health information are less appreciated. Self-monitoring can be a sensitive issue, because it may be perceived as a form of control and thus have a negative impact on the use and effectiveness of the app. The challenge is to personalise the relationship between user and tool as much as possible. This could include gaming elements[46] which may increase users' motivation to lose weight, for example.[43] A combination of tools along with their functions and features would be more appropriate than just a single method; for example, a web portal to support an app,[27] or telephone support (maximum 15 min).[27] Similarly, complementary personal coaching is required.[26,27,29,31,47] Finally, effectiveness depends on a high level of motivation,[43] and we observed that the main techniques used in apps aim to increase motivation.

Discussion

An insufficient process evaluation for MHApps

Our question was how do researchers explore the efficacy/effectiveness conditions of MHApps in experimental studies? To answer, we proceeded to a scoping review. Findings show that although process evaluation could shed light on the mechanisms of efficacy, as it would help to understand how an intervention works, in these studies this evaluation is insufficient to answer this question. In the studies analysed,

Table 2 – Characteristic of the articles according to the eight dimensions for analysis.

Articles	Characteristics of the user population	State of health	Determinant	Design	Tools		Activities included in the MHApps				Levels of action	Outcomes in terms of behaviour changes
					App	Connected device (Yes:present, No: not present)	Coaching			Web-based exchange forum		
							Text messaging (SMS, messenger, e-mail)	Face to face or working group	Tel			
Alley et al., 2014[24]	18–59 yrs male + female	No illness	Physical activity	Randomised Controlled Trial (RCT)	No	No	Yes	No	No	Yes	Individual	Behaviour change in progress and maintaining the new behaviour
B. Spring et al., 2013[25]	18–59 yrs over 60 yrs male + female	No illness	Physical activity and eating and other(s)	RCT	Yes	No	No	Yes	Yes	No	Individual	Behaviour change in progress
Batch et al., 2014[26] and Svetkey et al., 2015[31]	18–59 yrs male + female	No illness	Physical activity and eating and other(s)	RCT	Yes	No	Yes	Yes	Yes	No	Individual Collective	Behaviour change in progress and maintaining the new behaviour
Cadmus-Bertram et al., 2016[40]	18–59 yrs over 60 yrs Female	No illness	Physical activity and eating and other(s)	RCT	Yes	Yes	No	No	Yes	Yes	Individual Collective	Behaviour change in progress
Dennison et al., 2014[27]	18–59 yrs over 60 yrs male + female	No illness	Physical activity and eating	RCT	No	No	No	No	Yes	Yes	Individual	Behaviour change in progress
Hartman et al., 2016[22]	18–59 yrs over 60 yrs Female	No illness	Physical activity and eating	RCT	Yes	Yes or No	No	No	Yes	Yes	Individual	Behaviour change in progress
Hughes et al., 2011[42]	18–59 yrs over 60 yrs male + female	No illness + Chronic illness	Physical activity and eating and other(s)	RCT	No	No	Yes	Yes	Yes	Yes	Individual	Behaviour change in progress
Laing et al., 2014[43]	18–59 yrs over 60 yrs male + female	No illness	Eating	RCT	Yes	No	No	No	No	Yes	Individual Collective	Behaviour change in progress
Nguyen et al. 2013[28]	0–17 yrs male + female	No illness	Physical activity and eating	RCT	No	No	Yes	Yes	Yes	No	Individual Collective	Maintaining the new behaviour
Partridge et al., 2016[29]	18–59 yrs male + female	No illness	Physical activity and eating	RCT	No	No	Yes	Yes	Yes	Yes	Individual Collective	Behaviour change in progress and maintaining the new behaviour
Peacock et al., 2015[44]	18–59 yrs over 60 yrs male + female	No illness + Chronic illness	Physical activity	RCT	Yes	Yes	No	No	No	Yes	Individual	Behaviour change in progress

Pellegrini et al., 2012[30]	18–59 yrs male + female	No illness	Physical activity and eating	RCT	Yes	Yes or No	No	Yes	Yes	Yes	Individual Collective	Behaviour change in progress
Quinn et al., 2011[32]	18–59 yrs male + female	Chronic illness	Physical activity and eating and other(s)	Cluster Randomised Trial	Yes	Yes	Yes	No	Yes	No	Individual	Behaviour change in progress
Ratanawongsa et al., 2014[23]	18–59 yrs over 60 yrs male + female In hardship	Chronic illness	Physical activity and eating	Stepped Wedge Control Randomised Trial	No	No	No	No	Yes	No	Individual	Behaviour change in progress
Reid et al., 2012[33]	18–59 yrs over 60 yrs male + female	Chronic illness	Physical activity	RCT	Yes	Yes	Yes	Yes	No	Yes	Individual	Behaviour change in progress
Sangster et al., 2015[41]	18–59 yrs over 60 yrs male + female	Chronic illness	Physical activity and eating	RCT Cost utility analysis	Yes	Yes	No	No	Yes	No	Individual	Behaviour change in progress
Spassova et al., 2016[69]	18–59 yrs over 60 yrs male + female	No illness	Physical activity and eating and other(s)	RCT	No	No	No	No	Yes	No	Individual	Behaviour change in progress
Taveras et al., 2012[70]	0–17 yrs male + female In hardship	No illness	Physical activity and eating and other(s)	RCT	No	No	Yes	Yes	Yes	No	Individual Environment	Behaviour change in progress
van Berkel et al., 2014[45]	18–59 yrs male + female	No illness	Physical activity and eating and other(s)	RCT	No	No	No	No	No	Yes	Individual	Behaviour change in progress
van Vugt M. et al., 2013[47]	18–59 yrs over 60 yrs male + female	Chronic illness	Physical activity and eating and other(s)	RCT	No	No	Yes	Yes	No	Yes	Individual	Behaviour change in progress
Wayne et al., 2015[6]	18–59 yrs over 60 yrs male + female In hardship	Chronic illness	Physical activity and eating and other(s)	RCT	Yes	No	Yes	Yes	Yes	No	Individual	Behaviour change in progress

MHApps, mobile health applications.

Table 3 – Behaviour change techniques and change theories.

Articles	Behaviour change techniques (among the 16 BCTs' categories)	Behaviour change theories
Alley et al. 2014[24]	(1) Scheduled consequences (8) Feedback and monitoring (10) Social support (15) Shaping knowledge	Classic learning theories[34] Theory of planned behaviour[37]
B. Spring et al., 2013[25]	(8) Feedback and monitoring (9) Goals and planning (10) Social support (11) Comparison of behaviour (12) Self-belief	Transtheoretical model[21] Relapse prevention[36] Social cognitive theory[20] Theory of planned behaviour[37]
Batch et al., 2014[26]	(8) Feedback and monitoring (9) Goals and planning	Social cognitive theory[20]
Svetkey et al., 2015[31]	(10) Social support (15) Shaping knowledge	Transtheoretical model[21]
Cadmus-Bertram et al., 2016[40]	(9) Goals and planning (15) Shaping knowledge	
Dennison et al., 2014[27]		Social cognitive theory[20]
Hartman et al., 2016[22]	(10) Social support (15) Shaping knowledge	Classic learning theories[34]
Hughes, et al., 2011[42]	(5) Associations (8) Feedback and monitoring (9) Goals and planning	
Laing et al., 2014[43]	(2) Reward and threat (10) Social support (11) Comparison of behaviour	
Nguyen et al., 2013[28]		Classic learning theories[34]
Partridge et al., 2016[29]	(9) Goals and planning (15) Shaping knowledge	Classic learning theories[34]
Peacock et al., 2015[44]	8) Feedback and monitoring (9) Goals and planning	
Pellegrini et al., 2012[30]	(9) Goals and planning (15) Shaping knowledge	Social cognitive theory[20]
Quinn et al., 2011[32]	(8) Feedback and monitoring (9) Goals and planning (10) Social support	Transtheoretical model[21] Social cognitive theory[20]
Ratanawongsa et al., 2014[23]	(3) Repetition and substitution (8) Feedback and monitoring (14) Identity (12) Self-belief (15) Shaping knowledge	Ecological perspective[38]
Reid et al., 2012[33]	(3) Repetition and substitution (5) Associations (7) Natural consequences (8) Feedback and monitoring (9) Goals and planning (11) Comparison of behaviour (15) Shaping knowledge	Social cognitive theory[20]

although the judgement criteria were clearly identified for state of health or behaviour change (body mass index reduction, increase in physical activity, etc.), it remains difficult to capture what was really assessed, what MHApps actually work on and how:[29] what are the behaviour change mechanisms activated by MHApps, what are the underlying theories, how do the different components of MHApps work? Most articles do not provide an understanding of which informational and educational levers are used.[48] While authors reported a quantification of messages sent or received or connections made,[26,31] they did not specify the nature of the messages, their relevancy or their adaptability, despite this latter aspect being a factor of effectiveness.[49] Indeed, it is consistent with the paradigms of the health technology assessment.[50] These models are mainly used for medical devices, and guidelines exist such as the guide produced by the World Health Organisation[50] or the European Union guidelines,[51] but they aim to provide a list of criteria for appraising—according to a risk assessment model—the quality, acceptability, opportunity, suitability, use and feasibility of the apps used. In the prevention field, a framework is required to provide an assessment on the way MHApps help to change behaviour. No such framework exists. As an illustration, it is interesting to analyse how the authors characterised the factors of effectiveness/efficacy: ergonomics, adaptability, information sharing and social support, factors of individual motivation and access to the technology. Ergonomics relates to how the tools have to respond to their desirability. Adaptability drives motivation and helps the user maintain the new behaviour in his/her environment. Social support works if it has a precise objective but is variable from one person to another. Motivation and the factors influencing it such as access to the technology allow greater uptake of MHApps as well as enhancing their effectiveness in changing behaviour. Although these factors are interesting, they are not sufficiently studied or analysed to provide a deep understanding of the efficacy mechanisms in prevention MHApps: how do these factors influence the effect of the app? What are the mechanisms involved in this process? On whom do they work? In other words, MHApps were assessed as tools—through an appraisal of their characteristics—and not as behavioural interventions, i.e. through an explanation of the causal inferences between the tool's components, the individual's characteristics and the environment of use.

A need to consider literacy level in the issue of social inequalities

The influence of intervention on social inequalities is a major issue in the prevention field. We have shown above that the issue of social inequalities is poorly assessed and only considered in regard to access to technology, as the number of smartphones is growing rapidly. However, social inequalities include socio-economic background, geographical area but also education, notably literacy. In that respect, Gibbons et al.[52] propose the creation of a tool for people with limited resources to ensure that all users are readily able to use it and to ensure technical assistance for users. More recently, a review[53] showed that the digital divide in eHealth is a serious barrier that contributes greatly to social health inequality and suggests raising awareness of users' literacy level by creating eHealth tools that respect the cultural attributes of users and by encouraging participation among people at risk of social health inequality. This factor should

therefore be taken into account in designing and assessing MHApps.

A need to strengthen the existing assessment model

To address the knowledge gaps in the process evaluation, MHApps should be assessed under the same paradigms as those used to assess face-to-face interventions,[54,55] taking into account the complexity of prevention interventions, among other things by using underlying theories.[54,55] This involves better descriptions of the components of MHApps and how they interact and play out in behaviour changes. The use of taxonomies that describe active content, such as the taxonomy of BCTs,[18,19] should be encouraged as a way to both assess and design MHApps. In the same way, different components of MHApps can have an effect on certain change factors. In light of Michie's behaviour change wheel,[56] MHApps could influence the motivation, opportunity and capability to change behaviour. To trigger these factors,[56] various techniques need to be used. However, of 16 categories of BCTs, only four are generally used, all focusing on increasing motivation (shaping knowledge, feedback and monitoring, goals and planning and social support). Yet, we have also shown that apps mainly work on people who are already motivated. This could help explain why the use and effectiveness of MHApps are not maintained over time (under 6 months):[29,57] they increase existing motivation but remain insufficient to support people's capabilities to change and maintain their behaviours. For example, some BCTs[18] as 'Monitoring of emotional consequences' or 'Avoidance/reducing exposure to cues for the behaviour' could improve capability or opportunity. Hence, they could provide an in-depth support in change behaviour, but they are not reported in MHApps.

Similarly, this would also explain why theory-based MHApps seem to be used more effectively and for longer:[57–61] these MHApps integrate other behaviour techniques in addition to those linked to motivation and self-knowledge, as is the case in face-to-face prevention strategies. These techniques offer support that goes beyond motivation maintenance, such as coping strategies, cognitive restructuring strategies, environmental restructuring strategies, decision-making help, emotional control techniques, self-incentive, identity framing/reframing, etc.

Regarding the efficacy/effectiveness of MHApps, because of the lack of mechanism exploration (process evaluation), experimental studies are not conclusive in terms of the transferability of these apps beyond experimental conditions. The results are precisely reported but complex to interpret and to use pragmatically. For example, Spring et al.[62] show that effectiveness stems from a combination of messages. But how does one determine which messages or combination of messages are effective and are to be transferred if the black box of MHApps is not explained? Opening the black box of MHApps, such as all complex health interventions, is not only an heuristic issue but also a transferability and scalability issue, as described in the Medical Research Council guidance.[54] For all of these reasons, several authors have started to evaluate combined design to assess apps in prevention,[63] to enhance the transferability of the conclusions of efficacy studies.

Limits

The review includes articles from January 2005 to January 2017. A number of articles on MHApps have been published since 2017 but with no significant changes regarding to our conclusions; BCTs and behaviour change wheel are maybe little more used to analyse the conditions of effectiveness, but the most recent articles provide the same conclusions as well as about MHApps effectiveness as about the categories of BCTs involved (average between five and nine BCTs included into goals and planning, feedback and monitoring categories).[64–68]

To conclude, despite the number of theoretical works on behaviour change interventions, this review has identified a dearth of reporting on mechanisms in experimental studies on the efficacy/effectiveness of MHApps. Yet these studies are used to inform policy prevention. A particular finding, and problem, is that most MHApps have been analysed as tools rather than as prevention strategies. It therefore seems important to combine the paradigms relating to health technology assessment with an evaluation of complex interventions that includes mechanism to improve capability, opportunity and motivation and process evaluation. Thus, MHApps have to be built to complete the health professional's work. Therefore, health professionals and population must be actively involved in developing the intervention theories underpinning the way of actions of MHApps. This is a condition for improved assessments of MHApps in terms of effectiveness, transferability and scalability.

Author statements

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Authors' contributions

O.A. has made substantial contributions to the conception and design, data collection and analysis, drafting and critical review of the manuscript for important intellectual content. A.V.H., A.V., A.M.F., C.C. have participated in developing the review protocol, data collection and analysis and have contributed to the manuscript. J.P. and L.C. also contributed to this work. They made substantial contributions to the conception or design of the work and the acquisition, analysis and interpretation of data for the work. They drafted the work and revised it critically for important intellectual content. They give final approval of the version to be published. They agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of

any part of the work are appropriately investigated and resolved.

All the authors have read and approved the final manuscript.

Ethical approval

Not required (Scoping review).

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Competing interests

None declared.

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