







Effectiveness of mobile applications for behavioral changes in health: a systematic review

Efetividade de aplicativos móveis para mudanças comportamentais em saúde: revisão sistemática

How to cite this article:

Paula TR, Menezes AP, Guedes NG, Silva VM, Cardoso MVLML, Ramos ES. Effectiveness of mobile applications for behavioral changes in health: a systematic review. Rev Rene. 2020;21:e43845. DOI: <https://doi.org/10.15253/2175-6783.20202143845>

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ABSTRACT

Objective: to evaluate the effectiveness of mobile applications for behavioral changes focused in health. **Methods:** systematic review, from the PubMed, SCOPUS, Cochrane, PsycINFO, CINAHL, and Medline. The descriptors used were: Mobile applications and Health. The study used the protocol Preferred Reporting Items for Systematic reviews and Meta-Analyses, and the methodological quality was evaluated using the Joanna Briggs Institute® instrument. The final sample was made up of eight articles. **Results:** most randomized clinical trials showed that interventions with applications are potentially effective strategies to change behavior in health, especially when associated to other strategies in accordance to the specific population/context. The articles included in the review were in accordance to at least nine of the thirteen questions of methodological quality evaluation. **Conclusion:** the use of applications has impacts on behavioral change and contributes for positive results in the state of health.

Descriptors: Mobile Applications; Health; Software; Systematic Review; Health Behavior.

RESUMO

Objetivo: avaliar a efetividade de aplicativos móveis para mudanças comportamentais com foco na saúde. **Métodos:** revisão sistemática, a partir do PubMed, SCOPUS, Cochrane, PsycINFO, CINAHL e Medline. Os descritores utilizados foram: *Mobile applications e Health*. Utilizou-se do protocolo *Preferred Reporting Items for Systematic reviews and Meta-Analyses* e para avaliação da qualidade metodológica, o instrumento do Instituto Joanna Briggs®. A amostra final foi composta por oito artigos. **Resultados:** a maioria dos ensaios clínicos randomizados mostrou que intervenções com aplicativos são estratégias potencialmente efetivas na mudança de comportamento em saúde, principalmente quando associadas a outras estratégias, adequadas a um contexto/população específica. Os artigos incluídos na revisão contemplaram positivamente pelo menos nove dos treze questionamentos da avaliação da qualidade metodológica. **Conclusão:** o uso de aplicativos tem impacto na mudança de comportamento e favorece resultados positivos no estado de saúde.

Descritores: Aplicativos Móveis; Saúde; Software; Revisão Sistemática; Comportamentos Relacionados com a Saúde.

EDITOR IN CHIEF: Ana Fatima Carvalho Fernandes
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Introduction

Information and Communication Technologies (ICTs) were incorporated to all fields of human activity, especially due to the disseminated use of mobile devices, such as more versatile phones (smartphones) and portable devices (tablets) with access to wireless high-speed Internet. Applications for use in these devices have been offered to an increasing variety of fields of activity, be them for use in entertainment or to offer support to daily activities, including healthcare⁽¹⁻³⁾.

Mobile applications gained space due to their high usability, since they attend the needs of the individuals in many different situations due to their capacity of interacting and to the fast access to information, in addition to being practical. In the field of health, these applications have been developed to address subjects of interest of specific fields of action⁽⁴⁾, aiming, for instance, to diminish errors in therapeutic prescriptions⁽⁵⁾, encouraging healthy behaviors⁽⁶⁾, and allowing one to monitor patients from a distance⁽⁷⁾.

In addition, the use of this technology facilitates the adoption and integration of the adherence to treatment, while also promoting behavioral strategies through health-related messages, tracking goals, and encouraging behavioral change to improve the health situation of individuals⁽⁸⁾. It is widely known that, in the 21st century, the morbidity and mortality profiles have been related to behaviors in individuals that determine a standard of health and disease in the population⁽⁹⁾.

Therefore, it becomes clear that strategies that enable behavioral change are necessary, strategies that focus on health promotion, prevention, and/or on the treatment of diseases. From this perspective, studies in the field of Nursing suggest that the use of applications can bring positive results with regards to behavioral change, and in the control of diets in adults⁽¹⁰⁾.

However, simply making available applications that provide access to the information by the patient,

or to the patient's data by the health team, may not lead to measurable results in the quality of the control of the health of different populations⁽¹⁰⁾. The analysis of the technical characteristics of the applications available, including their cost, in addition to evaluations of their effectiveness, is necessary for these technologies to be recommended and inserted in the routine of care to the patient and/or client, as to attend to the demands and lead to effective improvements in the quality of care⁽¹¹⁾.

Evaluating the effectiveness of these tools becomes necessary with the advance of the technological production in health. To do so, the critical analysis of studies that tested applications in their respective fields of action may favor and enhance the use of these technologies. Therefore, this study aimed to evaluate the effectiveness of mobile applications for behavioral changes focused in health.

Methods

This is a systematic review that used the methodological principles prescribed in the 4th edition of the Joanna Briggs Institute Reviewers Manual⁽¹²⁾. The review protocol was based on the recommendations, directed for systematic reviews of effectiveness, including the relevance of the review; inclusion criteria; results, interventions, and comparisons; search strategies; selection procedures; processes and instruments of critical evaluation; development of data extraction; performance in the resolution of disagreements between reviewers; and approaches for the synthesis⁽¹³⁾.

To select the studies, the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) protocol was used. The review was carried out from October to November 2017, with information from PubMed and the databases SCOPUS, Cochrane, American Psychological Association (PsycINFO), Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Medical Literature Analysis and Retrieval System Online (Medline). The controlled

descriptors from the Medical Subject Headings (MeSH Browser®) and from the Health Science Descriptors (DeCS®) websites were used, with the research strategy: “Mobile application” AND “Health”. Articles in Portuguese, English, and Spanish were selected, with no specific time frame.

To formulate the review question, the PICOD strategy was used, in which P: population - people above 18 years old; I: intervention - use of mobile applications that involved behavioral changes in the field of health; C: comparison of interventions - people who used the application x people who did not; O: outcome - behaviors that promote health; D: design of the study - clinical trial. This strategy has an efficient structure for data searches⁽¹³⁾. Therefore, the guiding question was: Is the use of mobile applications in the field of health effective to provoke behavioral changes in individuals above 18 years old?

The inclusion criteria for the articles were: having, as the participants who are using the application, only people above 18 years old; clinical trials, lasting for any amount of time, with the main goal of testing the effectiveness of the mobile application in the promotion of behavioral change, focused in health. The selection process was carried out by two reviewers, and their disagreements were solved by the reaching of a consensus between them.

2127 articles were found (Pubmed: 240; Scopus: 481; Cochrane: 2; PsycINFO: 14, CINAHL: 294; Medline: 1.096). Their titles and abstracts were read to refine the search. From the articles found, 65 were selected to be read in full (Pubmed: 28; Scopus: 4; Cochrane: 0; PsycINFO: 3, CINAHL: 1; Medline: 30), and eight were selected to be part of the final sample. The reading was carried out by two researchers, independently. There were not disagreements. The flowchart of the exclusion of the articles read in full is in Figure 1.

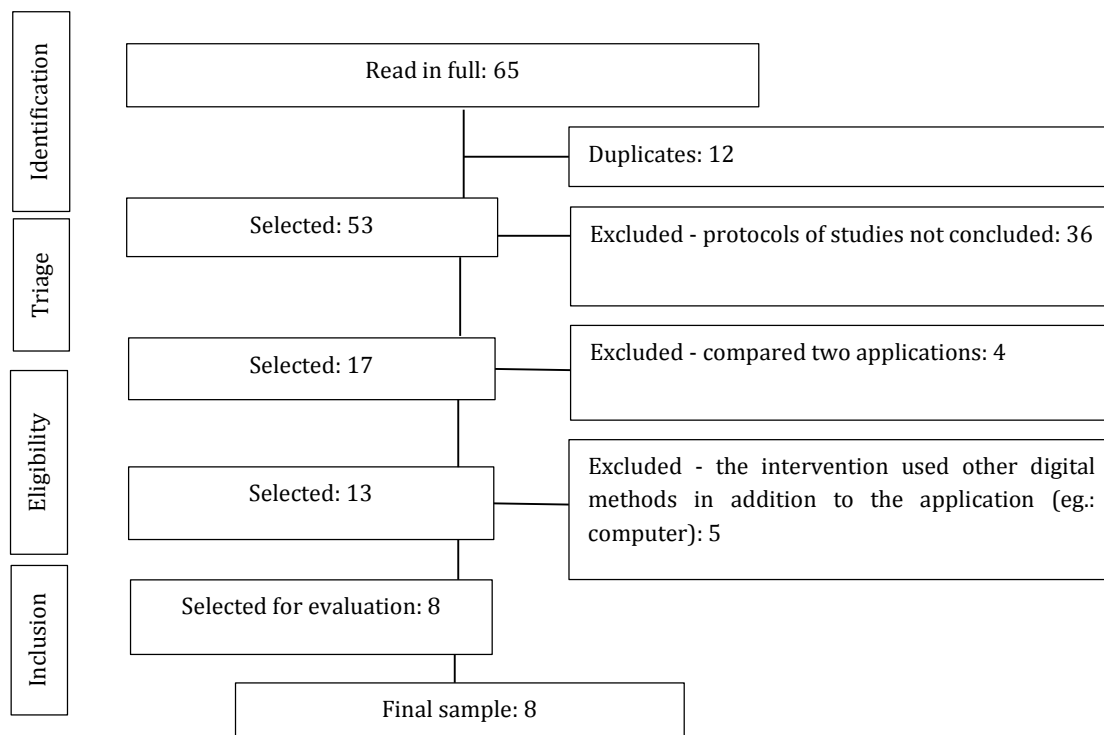


Figure 1 – Flowchart for the selection of the studies (PRISMA). Fortaleza, CE, Brazil, 2020

To evaluate the methodological quality of the studies, the instrument Critical Appraisal Checklist for Randomized Controlled Trials, by the Joanna Briggs Institute®, was used. It includes 13 questions, involving aspects on randomization; whether allocation of the participant groups was concealed; whether groups were similar at the baseline; whether participants were blind; whether those delivering treatment were blind; whether outcome assessors were blind; whether treatment groups were treated identically; whether there was follow up of the participants; management of interventions and groups; whether outcomes were measured in the same way for the groups; whether outcomes were reliably measured; whether an appropriate statistical analysis was used; and whether the trial design was appropriate. The studies were evaluated by two independent reviewers. Each question had the response options “yes” (Y), “no” (N), “unclear” (U), or “does not apply” (DNA).

To extract data, an adapted instrument⁽¹³⁾ was used that considered the method, the setting/context participants, interventions, and the conclusions by the authors. Also, data was extracted regarding the country where the research was developed, the authors, title, year, and journal of publication, in addition to main results. The reviewers found a consensus with regard to the evaluation of the methodological quality and data extraction.

Results

From the eight clinical randomized trials included in the review, four were indexed in Medline⁽¹⁴⁻¹⁷⁾ and four in PubMed⁽¹⁸⁻²¹⁾. They were published from 2015 to 2017. Four were developed in the USA and the others in Finland, Mexico, Ethiopia, and in the Netherlands. The clinical trials compared the use of mobile applications to other strategies to provoke behavioral change and improve the health of individuals above 18 years old (Figures 2 and 3).

Regarding the evaluation of the methodological quality, three answered “yes” in nine items of the evaluation^(14-15,17); two, in eleven items^(16,18), one, in twelve items⁽²⁰⁾; and two gave positive answers to all questions^(19,21). Three articles^(14-15,17) received negative responses to questions regarding identical treatment to the groups⁽¹⁴⁾, blind allocation of groups⁽¹⁵⁾, similarity of the groups at the baseline, and to blindness of participants, of those delivering the intervention, and of the outcome assessors⁽¹⁷⁾. Three questions were evaluated as “unclear”, two with regards to the blindness of participants⁽¹⁴⁻¹⁵⁾, four^(14-16,20) with regards to the blindness of those who delivered the intervention, and five^(14-16,18,20) with regards to the blindness of outcome assessors. Eight articles were considered in the composition of the sample of this systematic review.

Authors/Year	Age (years)	Interventions	Sample
Buller et al., 2015 ⁽¹⁴⁾	>18	Application Sollar Cel vs Usual Care	202
Svetkey et al., 2015 ⁽¹⁵⁾	18 – 35	Application Cell Phone Intervention for You (CITY) + Coaching vs Application Cell Phone Intervention for You (CITY) without coaching vs flyers	365
Anzaldo-Campos et al., 2015 ⁽¹⁶⁾	18-75	Application Dulce Project + care team vs Application Dulce Project + glucometer + care team vs Monthly visits	301
Martin et al., 2015 ⁽¹⁷⁾	18 to 69	Application Fitbug Orb + text messages vs Application Fitbug Orb without text messages vs No intervention	48
Karhula et al., 2015 ⁽¹⁸⁾	18 to 65	Application Personal Health Record + Set of dispositive for measuring + Coaching in health vs Usual care	595
Van der Weegen et al., 2015 ⁽¹⁹⁾	18 to 69	Application + Activity Sensor (It's Life! Program) vs Nursing Feedback	540
Lund et al., 2016 ⁽²⁰⁾	>18	Application Safe Delivery App vs Usual care	130
Mummah et al., 2017 ⁽²¹⁾	18 – 50	Application Vegethon + Weight lost Program vs Usual care + Weight lost Program	135

Figure 2 – Descriptions of articles, according to authors/year, age group, interventions, and samples Fortaleza, CE, Brazil, 2020

Journal	Countries	Objectives
JAMA Dermatol ⁽¹⁴⁾	USA	Evaluating, for the second time, a mobile application for smartphones (Solar Cell) that offers real-time advices on solar protection, in a clinical randomized trial.
Obesity ⁽¹⁵⁾	USA	Determine the effect of two behavioral weight-loss interventions, based on mobile technology (mHealth) in young adults.
Diabetes Technol Ther ⁽¹⁶⁾	Mexico	Evaluating the effectiveness of the <i>Project Dulce</i> model, with and without mobile technologies, in the glycemic control, and evaluating other clinical results in patients with type 2 diabetes.
J Am Heart Assoc ⁽¹⁷⁾	USA	Verifying the effectiveness of a mobile health intervention (mHealth), with components of tracking and text messages to increase physical activity.
J Med Internet Res ⁽¹⁸⁾	Finland	To evaluate whether a mobile application for health training, with support from a remote monitoring system, could be used to improve the quality of life related to health and/or clinical measures of patients with type 2 diabetes and cardiac diseases.
J Med Internet Res ⁽¹⁹⁾	Netherlands	To analyze whether an application for monitoring and feedback, in combination with a counseling program, would encourage physical activities more than the usual care, and evaluate the use of this tool in addition to the program.
JAMA Pediatr ⁽²⁰⁾	Ethiopia	Determining the effects of the safe delivery application (SDA) in perinatal survival, in knowledge, and in the abilities of health professionals in neonatal reanimation.
Int J Behav Nutr Phys Acta ⁽²¹⁾	USA	Testing the effects of a mobile application to increase vegetable intake among overweight adults who are trying to lose weight.

Figure 3 – Description of articles, according to journal, country, and objectives. Fortaleza, CE, Brazil, 2020

When comparing the use of the Solar Cell application, which offered advice on solar protection, to usual solar protection care in American adults, the intervention group used more broad-brimmed hats during seven weeks than the participants of the control group (23,8% vs 17,4%; $F=4,07$; $p=0,045$). Women who used the mobile application reported they used a combination of all solar protection measures more often than the men (46.4% vs 43.3%; $F=1.49$; $p=0.004$). Men and elders reported lower use of sunscreen lotions (32.7% vs 35.5%; $F=5.36$; $p=0.002$) and hats (15.6% vs 17.9%; $F=4.72$; $p=0.003$). The intervention prescribed the sending of 11 messages through the application, with a total time of 12 weeks. The use of the mobile application was associated to a better sun protection, especially among women⁽¹⁴⁾.

Among adults with overweight and obesity, the intervention with the definition of goals, games with challenges, and social support, delivered using the Cell Phone Intervention for You (CITY) was not superior to

the use of leaflets with information on healthy eating and physical activities. On the other hand, the group of participants who used the application in association to coaching sessions lost significantly more weight than those who were in the control group, throughout six months (net effect -1.92kg [Confidence Interval (CI): 3.17-0.67], $p=0.003$)⁽¹⁵⁾.

In patients with type 2 diabetes, the use of the Dulce Project, associated to the care of the team and to the glucometer, was effective, diminishing glycaated hemoglobin (HbA1c) in the intervention groups (-3.0%[-33mmol/mol]) and (-2.6% [-28.7mmol/mol]) when compared to the control group (-1,3% [-14.2mmol/mol]) ($p=0.009$ and $p=0.001$, respectively), during the 10 months of the study. Additionally, patients who received the intervention showed to have an improved knowledge about diabetes when compared to the control group. Researchers suggested integrating conventional methods and mobile technologies⁽¹⁶⁾.

The association of the Fitbug Orb application, focused on the management of physical activities and motivational messages, was more effective when compared to those who used the application but did not receive the messages, who walked 2,534 steps less (95% IC: 1318 to 3750; $p < 0.001$); and when compared to those who did not use the application at all, who walked 3,376 steps less (95% CI: 1951 a 4801; $p < 0.001$)⁽¹⁷⁾.

The use of the Personal Health Record application by diabetic and coronary patients, including coaching strategies and records that followed up pressure levels, glycemia, and the number of steps did not show statistically significant benefits after nine months of study. No improvements in the quality of life in health and/or in the clinical measures of the patients were found⁽¹⁸⁾.

According to a study, carried out in the Netherlands, people with type 2 diabetes and those affected by coronary diseases received, as an intervention, a program for the support to physical activity self-management, through the combination of a mobile application and a monitoring tool (It's Life! program). The control group received feedback from the nursing professional for six months. The results showed increases in physical activities after the intervention, when compared to the control group (mean difference 11.73, IC: 6.21-17.25; $p < 0.001$). The results were maintained three months after the intervention, suggesting that the combination between the application and the counseling tool is an effective way of encouraging physical activity⁽¹⁹⁾.

The Safe Delivery App, focused on the training of professionals for emergency obstetric and neonatal care, in Ethiopia, was associated to lower perinatal mortality. The scores of the skills in the intervention group of health professionals were significantly increased when compared to the control group at 6 (mean difference, 6.04; 95% IC, 4.26-7.82) and 12 months (mean difference, 8.79; 95% IC: 7.14-10.45), corresponding to 80.0% and 107.0%, respectively, above the

control level. Scores of knowledge were also higher in the intervention group, in comparison to the control group at 6 (mean difference, 1.67; CC: 1.02-2.32) and 12 months (mean difference, 1.54; CI: 0.98-2.09), corresponding to 39.0 and 38.0%, respectively⁽²⁰⁾.

The application Vegethon, developed in the United States, was effective in increasing daily vegetable intake in overweight adults. The tool, used for eight weeks, allowed for the definition of goals, for self-monitoring, feedback, and offered motivational activities. The daily consumption of vegetables was significantly higher in the intervention group than in the control group for both measures (adjusted mean difference: 2.0 portions; CI 95%: 0.1, 3.8, $p = 0.004$ for the Food Frequency Questionnaire; and 1.0 portions; CI 95%: 0.2, 1.9; $p = 0.002$ according to their recollection of the last 24 hours)⁽²¹⁾.

Discussion

This systematic review did not involve a specific clinical context, and the studies included were heterogeneous with regards to the populations involved and the ways in which interventions were applied, which are limitations to the definition of complementary strategies to the applications focused on behavioral changes. Another limiting factor was the use of "Health" as the single descriptor related to behavioral changes. This may have led to an underestimation of the number of publications.

Among the self-reported limitations in the studies included in the research, the following stand out: the use of self-reports to measure results⁽¹⁴⁾, the absence of social support and of the characteristics of the participants⁽¹⁵⁾, limitations in the time available to use the application, difficulties in finding information on the participant, and low number of lipid tests⁽¹⁶⁾, lack of professional interventions associated to the application investigated, especially considering motivational ones, and generalization of participants⁽¹⁷⁾, limited to other populations of patients and manage-

rial problems during intervention⁽¹⁸⁾, restrictions to the activities performed⁽¹⁹⁾, results limited to a specific location and population⁽²⁰⁾, and short time of intervention⁽²¹⁾.

The results of this review reiterate that the use of applications by people above 18 years of age can be understood as an effective strategy in health promotion that shows promise, especially when associated to other strategies, that are adequate to the specific population/context. From this perspective, the use of mobile applications can contribute and facilitate behavioral changes in health, in many different fields.

The association with other technologies was tested in six studies^(15-19,21). Only one of them⁽¹⁸⁾ had a result that did not prove its effectiveness. Both applications, tested in isolation^(14,20) were considered to be effective tools to monitor behavior. Considering the variety of mobile applications focused on positive health results, both as isolated strategies or in association to other technologies, it is essential to understand the particularities of each target audience and adjust the technology, considering the focus of the intervention and the context involved.

The appeal of smartphones for assistance in the promotion of health is in accordance to the current trend of people seeking health information through mobile devices⁽²²⁾. The functioning of mobile applications has the potential to transform the practice of health and the behavior of individuals⁽²³⁾.

The fast lifestyle of the population favors the valuing of a convenient and fast access to programs to change health behavior that offer information and advice, self-monitoring in real time, feedback, reinforcement, social support, and rewards "on the run"⁽²⁴⁾.

Researches show that the use of this tools is more common among females and younger adults^(22,25), as it is to those who have a personal interest in new technologies and positive attitudes with regards to smartphone applications and perceived benefits from their use. On the other hand, the population was not very diverse, which is a limiting factor for the use of

applications as a means of health interventions for solar protection⁽¹⁴⁾.

The use of applications had a positive impact in the adoption of healthy life habits with regards to eating habits⁽²¹⁾, weight loss⁽¹⁵⁾, and the practice of physical activity^(17,19). Despite its positive results, the need for approaches that test the use of applications in health still stands out, since the theme is recent and there are restrict evidences^(17,21).

Interventions from applications, associated to complementary strategies, were the most used and showed great promise in regard to behavioral changes. Coaching sessions in overweight and obese individuals⁽¹⁵⁾, care from the health team and the use of the glucometer by people with diabetes type 2⁽¹⁶⁾, as well as tools to follow up and advise patients with coronary disease and diabetes type 2⁽¹⁹⁾, were important complementary strategies to improve the health state.

On the other hand, a similar study found that the application, when disassociated to the strategy of monitoring pressure levels, glycemic levels, and the steps of patients with diabetes and coronary disease, was not effective⁽¹⁹⁾.

Considering the many factors that involve and determine the efficiency of a mobile application, and the particular limits of each study, these tools are gaining space in health due to their positive impact in behavior and in the improvement of the health state of individuals. Hopefully, this study will be an encouragement for further researches using applications, especially for nursing health professionals to use in their field of action, considering the contributions brought by these tools.

The importance of a careful development of the applications is necessary, with adequate scientific and technical bases, and later tests to their clinical effects in different contexts, also involving populations with difficulties in accessing the Internet and information technology. It was not possible to carry out a meta-analysis, due to the variety of the data described in the articles included in the review.

Conclusion

Applications are effective tools to improve the health behaviors of individuals, although a better control of their development and implementation, associated or not to other health promotion strategies, is necessary. This will impact in the behavioral changes and in the improvement of positive states of health.

The efficiency and the viability of the use of health applications are a reality, considering the fast growth of health technologies. However, the importance of high-quality clinical evidences that have reliable therapeutic implications and impact health stand out.

Collaborations

Paula TH, Menezes AP and Guedes NG contributed for the conception of the project, for data analysis and interpretation, article writing, to the relevant critical review of the intellectual content, and to the final approval of the version to be published. Silva VM, Cardoso MVLML and Ramos ES collaborated through a relevant critical review of the intellectual content and the final approval of the version to be published.

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