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Mobile Applications to Quit Smoking. A Systematic Review

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Abstract. In an era in which the prevalence of smartphones and their associated applications has skyrocketed, it is relevant to explore the applications of these devices to promote public health, specifically, smoking cessation. The main objective of this study was to determine which smoking cessation applications have been developed considering empirical evidence. In relation to the applications tested or evaluated, in the systematic review carried out it was observed that one of the techniques that offers the best results is acceptance and commitment therapy (ACT). Likewise, it was observed that those applications that were not based on a solid technique did not show such favorable results. It is important to note that most of the tested applications with published results were not available in the application stores. The results of the present study shed light on the applications tested and evaluated and are consistent with those of meta-analyses and reviews carried out by other authors.

Keywords: Mobile Application · Smoking Cessation · Systematic Review

1 Introduction

One of the most prevalent interventions in recent years for the prevention and treatment of smoking is the use of mobile applications. This is because smartphones have become an integral part of our daily lives and, with it, the use of mobile apps. Mobile health technology (mHealth) represents a promising tool for engaging patients in their own healthcare given that the majority of individuals own and regularly use a mobile phone. Consequently, mHealth constitutes an optimal medium for the delivery of health information [1]. The use of mobile health applications has been demonstrated to result in enhanced levels of autonomy and an augmented sense of self-efficacy. Mobile health apps have the potential to assist individuals with and without clinical diagnoses in the promotion of desired behaviors [2].

Several systematic reviews and content analyses have been conducted to assess the efficacy of mobile health apps. A few studies have demonstrated the efficacy of mobile apps in modifying health-related behaviors (e.g., [3, 4]). However, the evidence is not entirely conclusive, as it has been observed that there were no statistically significant changes in the abstinence rate with smoking cessation apps. Consequently, few mobile apps are considered suitable as intervention strategies [5–7]. Indeed, content analyses

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of mobile apps for smoking cessation indicate that, despite the large number of apps available, they tend to have simplistic content [8, 9].

Consequently, despite the plethora of available apps, the scientific community asserts that it is imperative that the efficacy of the treatments they encompass be validated, given that on numerous occasions they fail to align with the established clinical guidelines or include therapies that have been empirically validated [6, 9–12].

2 Aim of the Study

A review of the literature on the topic was conducted based on the above and following the study by Haskins et al. [6] and García-Pazo et al. [10]. Articles of mobile apps for smoking cessation that have been tested were selected based on the selection and exclusion criteria detailed below (e.g., articles that do not have app evaluation results or those that target specific groups). The following specific objectives were thus identified:

1) To identify which studies, exist with results on the testing of mobile phone applications (apps) for smoking cessation.
2) To analyze the results obtained in the published studies.

3 Method

In order to address research objectives 1 and 2, a systematic review of the published scientific literature on the validation of the efficacy of mobile applications for smoking cessation was carried out. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement was adhered to in accordance with the guidelines for the correct conduct of systematic reviews. The PRISMA [13] statement, which supersedes the 2009 iteration, delineates the way publications pertaining to systematic reviews and meta-analyses should be presented, reflecting the methodologies employed for the identification, selection, evaluation, and synthesis of studies [14]. The following section provides a detailed account of the elaboration process, outlining the various phases involved.

3.1 Systematic Search

A systematic search was conducted in October 2021 in PubMed, Scopus and Web of Science (Medline, Scielo), with the results linked to publications from 2011 (inclusive) to 2021. The combination of search terms that yielded the most relevant results in both search engines was as follows:

((mobile_application OR mobile_app) OR smartphone_app) AND ((smoking_cessation OR quit_smoking) OR stop_smoking).

Specifically, 67 results were obtained from PubMed, 318 from Scopus and 1,116 from WOS. Before proceeding to the selection of articles, inclusion and exclusion criteria were defined.

Inclusion Criteria: (1) The studies must be empirical research and not reviews, single case studies, books or book chapters; (2) The studies should be validation studies of the efficacy of the intervention; (3) These were studies in which a mobile application for smoking cessation was validated (not a web page or other tool (e.g., text messages only)); (4). Published between 2011 and 2021; (5) Appearance of any of the search terms in the title; (6) Study participants older than 18 years of age.

Exclusion Criteria: (1) Studies focusing on a substance other than tobacco (e.g., cannabis); (2) Studies conducted on samples with mental pathology, pregnant women and studies dealing with several addictions at the same time (e.g. alcohol and tobacco, marijuana and tobacco…); (3) Studies in which the mobile application has not been tested (i.e., they only describe the design and development procedure, but without results); (4) These are e-cigarette smoking cessation apps (only studies of "traditional" tobacco); (5) Complementary applications to other intervention such as pharmacological); (6) The studies focus on smoking cessation apps aimed at non-daily smokers.

In accordance with the criteria, and only after reading the title, 78 articles were considered adequate (after eliminating 44 duplicates among the databases). We proceeded to read the abstract and, based on this reading, 59 articles were discarded, mainly for not including results (n = 21), for not being empirical studies or not being clinical trials (n = 11), for not being a mobile application, but a web page or sending text messages or comparing both (n = 16), for combining several methods (e.g., drugs) (n = 3), and for not being empirical studies or not being clinical trials (n = 11), for not being a mobile application but a web page or sending text messages or comparing both (n = 16), combining several methods (e.g., pharmaceuticals) (n = 3) and for focusing on very specific age groups (e.g., minors) (n = 5) or not including daily smokers (n = 3). Finally, 19 articles met the inclusion criteria and were selected for the systematic review.

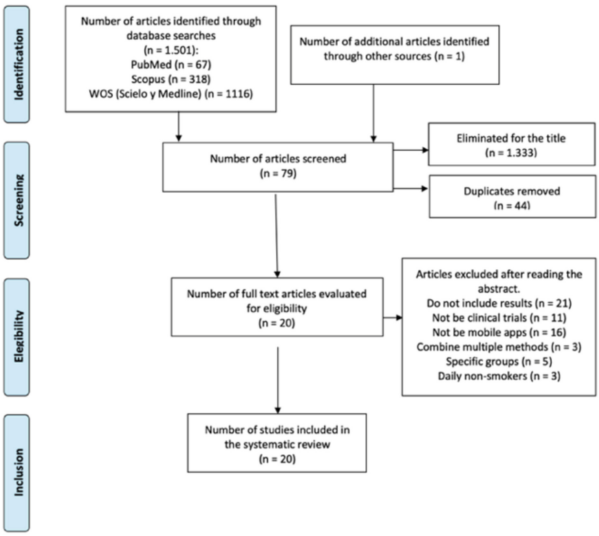

Fig. 1. Flow chart of selected articles.

3.2 Manual Search

Following the selection of the 19 studies and a comprehensive examination of their references, a new article was included that had not been indexed in the databases. This article was included because it yielded particularly relevant results. Finally, Google Scholar was employed with various combinations of the search terms initially identified to ascertain whether any article that should have been included might have been overlooked. Scopus was also re-examined. The searches did not yield any new studies that met the inclusion criteria. Consequently, the systematic review included 20 empirical articles published between 2011 and 2021, all of which were in English (see Fig. 1).

4 Results

The subsequent analysis is presented in the order deemed most relevant to facilitate the understanding and integration of the results. As a preliminary observation, it is notable that a considerable number of works and mobile applications for smoking cessation are available for both Android and iOS systems. Nevertheless, a significant proportion of these studies fail to meet the established selection criteria. Following an exhaustive analysis of the 20 selected studies, we have identified and extracted the most pertinent aspects in accordance with the objectives of our work.

Firstly, five of the selected studies employ Acceptance and Commitment Therapy (ACT; [15]). Acceptance Therapy focuses on increasing the willingness to experience the "here and now" of physical cravings, emotions, and thoughts while facilitating value-driven behavioral changes. Consequently, the term "acceptance" is used to describe the process of accommodating intense physical cravings (e.g., urges to smoke), emotions (e.g., sadness that triggers smoking), and thoughts (e.g., thoughts that trigger smoking). In this context, the therapy is focused on what is deeply meaningful to people, namely their values, in order to motivate and guide specific action plans (e.g., smoking cessation) [15, 16].

Bricker et al. [17] developed the SmartQuit app (version 1.0.) based on the ACT technique and compared it with an app developed by the National Cancer Institute (QuitGuide). The results of the study demonstrate the efficacy of the SmartQuit app in comparison to the QuitGuide app. Users of SmartQuit exhibited greater utilization of the app, with an average of 37.2 instances of app opening, in contrast to 15.2 instances for QuitGuide users. Additionally, abandonment rates are higher for SmarQuit users (13%) than QuitGuide users (8%).

Likewise, Heffner et al. [18] conducted a study to assess which ACT components of the SmartQuit app were most used by users. They observed that only two of the 10 most used functions were prospectively associated with quitting smoking: viewing the quit plan and tracking the practice of resisting urges. Conversely, the utilization of ACT skills was observed in a smaller number of participants ($n = 43$), yet this was found to be significantly associated with cessation ($p = 0.01$).

Bricker et al. [19] conducted a study on a new version of SmartQuit, SQ2.0, which included modifications based on functions identified by Heffner et al. [18] as predictive of smoking cessation. SQ2.0 prompted users to complete a smoking cessation plan and select a quit date, unlike the unstructured and non-sequential SQ1.0. Results showed

greater user satisfaction with SQ2.0. Among the 24% who completed the program, the quit rates were 33% for 7-day point prevalence, 28% for 30-day point prevalence, and 88% reduced their smoking frequency.

Along these lines, and with the same application, Zeng et al. [20] observed that fully adherent users (24%) were four times more likely to quit smoking. Once more, adherence to the app and the use of specific ACT theory-based components were found to predict quitting.

Years later, Bricker and colleagues [21] conducted a two-group clinical trial to compare the iCanQuit app developed by the authors with the QuitGuide app (from the National Cancer Institute, mentioned above). In this case, the iCanQuit app teaches ACT skills to cope with the urge to smoke, stay motivated and prevent relapse. Once more, the authors observed that the use of the iCanQuit app in comparison to the QuitGuide app was associated with a greater likelihood of quitting smoking, specifically 1.49 times more.

Continuing with cognitive therapies, Rajani et al. [22] conducted a study to test the efficacy of mobile apps for smoking cessation based on Cognitive Behavioral Therapy (CBT). For this purpose, they employed two mobile applications incorporating CBT components: Quit Genius and Kwit. After the study it was observed that users exhibited enhanced self-efficacy and motivation to cease smoking.

Schwaninger et al. [23] conducted a simple trial to test the SmokeFree buddy app with Behavior Change Techniques (BCT). Analyses revealed no significant effect in the intervention group on self-reported and CO-verified daily smoking abstinence at the quit date and 3 weeks later. Nevertheless, the number of cigarettes smoked per day (CPD) was lower at the quit date and 3 weeks later in the intervention group than in the control group.

Herbec et al. [24] conducted a clinical trial with a two-group design. The study compared the BupaQuit app (based on SmokeFree28) with craving management tools (CMT). The CMT tools included craving control, game to promote distraction, videos of stories of smokers trying to quit, guided relaxation routines, and tips. The study also included a version of the same app without the CMT tools. In this instance, the researchers observed no discernible differences between the control and intervention groups. It was observed that the incorporation of CMT tools did not influence cessation, and the limited engagement with the application may have contributed to this.

Roos et al. [25] examined the Craving to Quit app, which integrates ecological momentary assessment (EMA) with mindfulness training. EMA entails the real-time sampling of subjects' behaviors and experiences. The study compared the efficacy of the Craving to Quit app (which incorporates mobile mindfulness training with ecological momentary assessment [EMA]) to a control app (which only includes EMA). The results demonstrated that the use of the Craving to Quit app, in conjunction with elevated cravings at the initial stage of smoking cessation, led to a notable reduction in the number of cigarettes smoked per day from the baseline to the six-month follow-up. A year later, Garrison et al. [27] employed the app once more to ascertain whether mobile mindfulness training enhanced smoking cessation rates. Although no significant difference in smoking abstinence was observed between the treatment and control groups

at six months, the results indicated that mindfulness training was associated with a reduction in smoking rates compared to the control group.

Janes et al. [28] developed an application based on mindfulness training (MT). The authors conducted a comparative analysis of the intervention app with the QuitGuide app (previously mentioned). The researchers observed that users of the app exhibited a reduction in cigarette smoking. A significant correlation was observed between a reduction in the reactivity of the pre-conscious cognitive control (PCC) system to smoking cues and a decrease in cigarette smoking in the intervention group ($r = .39$, $p = .02$). In post hoc analyses, it was observed that this association was moderated by sex. Specifically, women exhibited a stronger correlation between the reduction in PCC reactivity to smoking cues and a decrease in cigarette smoking ($r = .49$, $p = .03$) than men ($r = -.08$, $p = .79$).

In a study published in 2019, Goldenhersh et al. [29] developed and tested the efficacy of the MindCotine application. To this end, they conducted a randomized controlled clinical trial of the app, which included a self-administered virtual reality treatment combined with mindfulness. The follow-up rate on day 1 was 93%. At the conclusion of the intervention period, 23% of participants in the treatment group had achieved abstinence, in comparison to 5% in the control group ($\chi 2 = 8.3$; $p = .004$). Furthermore, the treatment group demonstrated sustained abstinence of 33% at 90 days.

In contrast, there are other applications based on CO breath testing, such as COach2Quit. Krishnan et al. [30] observed that, after one month of using the app, one of the participants in each group (control and intervention) had successfully quit smoking. Nevertheless, 91% of the participants in the intervention group expressed a preference for using COach2Quit to assist them in quitting smoking.

Dallery et al. [31] evaluated the mMotiv8 application, which was designed to facilitate the capture of CO samples and the submission of CO samples (via CO graphs). Of the total number of participants ($N = 14$), 89% of the samples were negative during treatment. The results indicated that the application was perceived as highly usable and acceptable by the participants, with 85% of the requested samples being submitted.

Iacovello et al. [32] developed the Clickotine app based on the US clinical guideline (USCPG) for smoking cessation. The app is designed to provide users with counseling and encouragement, assess their willingness to quit, improve motivation, provide information about cessation, offer social support, connect users with a quitline, and provide follow-up support. Additionally, the intervention components are tailored to the individual, as the USCPG also recommends tailoring these functions as much as possible to maximize their effectiveness. The results demonstrated that of the 365 participants who completed the process, 51.5% reported abstinence for seven days and 29.9% for 30 days following the use of the app.

In a study conducted by Huh et al. [33], the efficacy of MyQuit USC (MQU) was tested. The app employs a just-in-time (JIT) approach to provide personalized interventions designed to facilitate behavioral change. This is achieved through the use of reminders (IIs) or specific plans of where and when to initiate a particular action, which create specific behavioural responses (e.g., I will leave cigarettes in the glove box) to specific cues (e.g., when I drive) for the achievement of complex goals (e.g., quit smoking). The authors observed that the receipt of a JIT reminder reduced the likelihood of

smoking for participants using their own phones. The results demonstrated that when participants followed the recommended reminder, they exhibited a reduced likelihood of smoking.

Baskerville et al. [34], conducted a study to evaluate the efficacy of the Crush the Crave (CTC) app in comparison to a control app. CTC is based on the STAR (listen, plan, do, act, and study) technique. In this instance, there was no significant difference in the rates of continuous abstinence at six months and 30-day point prevalence abstinence at six months between the CTC and the control app.

BinDhim et al. [35] evaluated the efficacy of an interactive cessation decision support app in comparison to a static information app. The app included four main components: (1) information on smoking cessation options, with their benefits and harms; (2) daily motivational messages (push notifications); (3) a quit diary; and (4) a follow-up. The results indicated that individuals who received the decision support app were more likely to remain abstinent for a longer duration, at both one-month and three-month follow-ups.

Affret and colleagues [36] developed the e-TIS app. The authors did not explicitly mention any specific technique or tool they utilized in the design of the app. The application comprised 16 distinct activities, eight questionnaires, 170 text messages or email notifications, and a push application with diverse purposes. In this case, there was no discernible difference between the e-TIS and control groups with respect to the outcome variables. Nevertheless, participants in the e-TIS group who had been exposed to the application for a longer period exhibited a higher dropout rate.

Finally, it has been observed that including elements such as Serious Games in smoking cessation apps can be effective. Pallejà-Millán et al. [37] developed Tobbstop and conducted a cluster randomized clinical trial. The app was based on games adapted to the abstinence process and motivational tools. With this, higher levels of abstinence were observed in the intervention group. Moreover, users who used the application more frequently were more likely to be non-smokers at the 12-month follow-up.

5 Discussion and Conclusions

The main objective of this study was to determine which smoking cessation apps have been developed taking into account the empirical evidence.

Of the apps included in the systematic review, only four were located in the AppStore and GooglePlay: Craving to Quit (available for Android and IOS devices but for a fee, otherwise the user cannot access the program), Quit Genius (available on both platforms, but only in English; in addition, the app requires the user to have a registered email and password, so its use is restricted), Kwit and MindCotine (available for Andoid and IOS). Also available on both platforms is the application that some of the aforementioned studies use as a control application: QuitGude, developed by the National Cancer Institute of the U.S. However, this application is only available in English. In this sense, coinciding with previous studies, it is concluded that most available mobile apps include simplistic elements (e.g., [8, 9, 38, 40]).

The results of the present study are consistent with those of meta-analyses and reviews by other authors (e. g. 38, 40]. In general, although much evidence-based studies have been shown in this review, it is certain that in the app stores very few applications are

based on empirical evidence (e.g., [6, 22, 39]) and the results are heterogeneous (e.g., [3, 40]).

The study presents some limitations, first, the search performed in the systematic review may not have included any relevant terms. Likewise, focusing only on published articles with results of application effectiveness provides a solid base of applications that have been examined and accepted as effective by the scientific community, but does not allow consideration of other effective health applications available to consumers, many of which are also based on theories and have an empirical basis.

In conclusion, it is relevant to explore the applications of these devices to promote public health, specifically smoking cessation. In this regard, the present study sheds light on the applications tested and evaluated.

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