

Digital interventions in smoking cessation – a brief overview of systematic reviews and meta-analyses

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Digital health includes a variety of modern methods that may support smoking cessation. In light of increasing interest in digital health interventions and the widespread digitization of the digitalization process in Europe, it seems relevant to assess its efficacy. This review aims to present the current knowledge regarding using digital interventions for tobacco cessation in different population groups. The PubMed and Google Scholar databases were searched for systematic reviews and meta-analyses regarding digital health interventions in smoking cessation. It was found that a wide range of methods have been studied for supporting smoking cessation. Digital interventions offer encouraging tools for the general population in health education but also for smokers and specific groups of patients in smoking cessation. Despite the promising results of some individual studies, most of the systematic reviews emphasized the need for further research and better-quality data to assess the efficacy of this approach.

Key words: digital health, smoking cessation, mobile health, tobacco, cancer prevention

Introduction

Tobacco cessation remains one of the greatest concerns of public health and is responsible for more than 8 million deaths each year [1]. It has been strongly emphasized that there is a need for interventions in smoking cessation and prevention strategies to reduce tobacco-related health and economic burdens on societies. With the proliferation of digital solutions and the incorporation of artificial intelligence, the availability of tools designed to support various health interventions has expanded significantly. It seems that mobile tools, supported by artificial intelligence or not, could become an effective approach to modifying lifestyle, including interventions in smoking cessation [2]. The increasing number of published works on digital intervention for smoking cessation is focused on the efficacy and relevancy of this solution compared to offline support or other available strategies to support smokers. Digital

health interventions have proven particularly valuable for smokers during the COVID-19 pandemic, especially as social distancing restrictions limited access to traditional healthcare settings and smoking cessation centers. These digital solutions offered a practical alternative, ensuring individuals could still receive support and guidance in their journey to quit smoking despite the limitations imposed by the pandemic [3].

There is a variety of digital health intervention solutions that can be implemented to support smoking cessation. Digital health is a comprehensive concept that includes different technologies and strategies to improve healthcare. While mobile health (mHealth) utilizes mobile devices, eHealth uses a wider range of electronic technologies. Telemedicine, on the other hand, is specifically concerned with providing healthcare services remotely. These interconnected concepts frequently collaborate to establish a more inclusive and readily accessible

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healthcare environment. The type of digital intervention may differ depending on the need it is supposed to cover. According to the Classification of Digital Health Interventions v 1.0 provided by the World Health Organization, interventions in digital health may include interventions for clients (population groups that require some health intervention), health care providers, health systems, resource managers, or data services [4]. Digital health interventions are designed to tackle specific challenges within the health system, including issues such as inadequate supply of commodities, healthcare professionals' poor adherence to clinical guidelines, limited access to data or information, and a notable percentage of patients disengaging from the treatment plan. Various digital interventions may be employed depending on the unique needs of specific patient groups and the challenges they aim to address. Nevertheless, further research is needed to ascertain their efficacy in smoking cessation.

This review aims to present the current knowledge regarding using digital interventions for tobacco cessation in different population groups.

Material and methods

PubMed and Google Scholar databases were searched between September and October 2023 using the keywords "digital intervention", "smoking", or "tobacco cessation". Results older than five years and those not within systematic reviews and meta-analyses were excluded. The articles must have been fully available in English. Articles were screened for relevance to the topic and compliance with search criteria. The results were categorized into groups based on the type of patients included in the studies, which were as follows: general population, smokers, pregnant women, specific clinical conditions, and others.

Results

The research yielded 59 results in response to the selected keywords and inclusion criteria. This article includes descriptions of 27 papers that met the criteria, while 29 were excluded for not being directly relevant to the topic. Additionally, two papers were excluded as they focused on cannabis use rather than tobacco.

Figure 1 illustrates the scientific interest in digital health interventions. Since 2016, there has been a fourfold increase in research on this topic, indicating a growing trend in scholarly attention to digital health interventions, outlining the growing interest in this field.

General population

Smoking is a problem affecting the whole of society. Therefore, any health intervention should address a wide spectrum of the population. Finding a suitable communication channel for many stakeholders and policymakers to meet people's educational needs in a constantly evolving online environ-

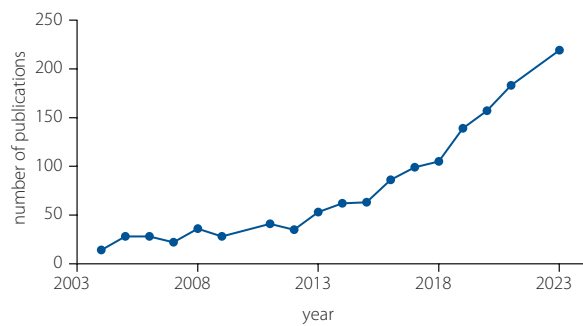


Figure 1. The scientific interest in digital health interventions in smoking cessation

ment remains challenging. The following systematic reviews present the current knowledge about digital health interventions for smoking cessation for the general population. One of the systematic reviews by Gold et al. concluded that digital interventions exhibit limited positive impacts on behavior related to health, namely: smoking, alcohol consumption, and interventions addressing both diet and physical activity [5]. The modest effects could stem from the treatment's low efficacy or non-adherence. Based on an analysis of 28 reviews, the authors also concluded that interventions delivered through the Internet, mobile devices, and computers positively affected smokers. However, in a study by Thornton et al., which encompassed various types of smartphone-based approaches to key lifestyle behaviours, the authors asserted that there is some evidence supporting the reliability and validity of using smartphones in addressing tobacco use [6]. Mobile devices can be used to assess and monitor smoking behavior. In this study, the authors referred to several studies where tobacco use was measured with smartphones. Although the results from some individual studies included in the systematic review were promising, the authors concluded that further research is needed to establish the validity and reliability of these objective approaches.

Moreover, the studies typically utilized very small sample sizes. In turn, the review by Katie Newby et al. revealed that some of the automated digital health interventions might strengthen self-efficacy among participants, which is a strong health determinant [7]. Supporting self-efficacy might be useful in strengthening positive health behaviours and encouraging smoking cessation. In a systematic review by Aggarwal et al., the authors summarized evidence for using AI-delivered chatbots to improve types of health behavior in various populations. As mentioned previously, AI-delivered chatbots provide, among others, personalized services and conversation space without judging or scalability to large and varied populations [8]. In general, AI chatbots were described as holding significant promise for integration into existing behavioral services due to their ease of integration, the potential for being cost-effective, accessible, scalable, and sustainable, but also their capability to deliver services to vulnerable populations on

sensitive issues in a non-stigmatizing and engaging manner. Despite the promising results, the authors highlighted limitations and recommended caution regarding implementing this solution into practice due to the need for more high-quality evidence from larger studies.

Regardless of the technology employed, mHealth-driven interventions represent a promising strategy to tackle the issue of non-communicable diseases. A study by Godinho et al. posited that mHealth can transform services from disease-centered to people-centered [9]. However, the authors underscored the necessity for high-quality and well-planned studies to furnish evidence on the efficacy of such a solution.

Digital interventions also emerge as an effective solution for meeting the needs of vulnerable groups. Community-serving organizations can employ various communication strategies to promote health and encourage healthy behavior. One of the reviews included digital health interventions dedicated to vulnerable populations such as low-income pregnant women, parents of young children, and adolescents. In the study by Eppes et al., it was presented that these groups manifested moderate engagement and favorable reception of digital media health campaigns implemented by community-serving agencies [10]. However, the impact of these strategies on enhancing health behaviors remained inconclusive. Using digital interventions in health promotion-focused communication enables reaching a broader and more diverse audience, making it a promising approach for campaigns targeting vulnerable populations. It is particularly noteworthy considering these populations' widespread use of mobile devices.

Noteworthy, digital solutions provide a wide range of information hubs and can become an impactful tool in the health education of society. Social media remains one of the most powerful tools for disseminating information. However, online content is almost impossible to control; therefore, the risk of spreading misinformation on health topics is significant. A study by Suarez-Lledo et al. revealed that the percentage of false health information in social media is very high [11]. The strongest relationship found was on Twitter and referred to tobacco products and drugs.

Smokers

Most of the reviews included in this work stated the positive impact of digital health solutions on smokers. A systematic review by Amri et al. revealed that digital interventions have been effective in promoting smoking cessation, leading to higher rates of abstinence [12]. However, the authors emphasized the need to assess the enduring effects of these digital interventions on smoking cessation outcomes. One of the methods used in smoking cessation is utilizing smartphone apps. In the study by María Barroso-Hurtado et al. the findings suggested that smartphone apps designed for smoking cessation are promising since they can be effective tools to help individuals quit smoking [13]. Mobile health apps can complement established

conventional cessation treatments. However, more research with robust methodological quality is needed to accurately determine the impact of mobile apps, either alone or combined with face-to-face contact, on smoking cessation outcomes.

Moreover, future studies should design smoking cessation apps that adhere to standard guidelines and employ rigorous methodologies, including sample size calculations, intention-to-treat analysis, and longer follow-up periods. Due to this field's emerging development, future research is expected to address current limitations to draw clear conclusions. Another recognized approach in digital health interventions for smokers involves using Conversational Agents. However, while this solution appears to be an innovative and modernized approach, its acceptability and efficacy in supporting smoking cessation still need to be determined. Conversational agents can provide a non-judgmental space for supportive conversations tailored to specific populations. However, this approach excludes those without access to mobile devices or the Internet and individuals with cognitive function deterioration who may face challenges in utilizing such a tool. Research by Linwei et al. outlined that the success of Conversational Agents for smoking cessation lies in their effectiveness and acceptability [14]. However, a more thorough evaluation necessitates the standardization of reporting and the design of these agents. While individual interventions have proven effective in smoking cessation, particularly among those with disadvantaged socioeconomic positions, there is a compelling need for additional research on AI-supported solutions to enhance and address these interventions [15].

Smokers with severe mental illnesses

Agulleiro et al. raised a question on the use of digital health interventions for smokers with severe mental illnesses [16]. The study highlighted the potential of digitally delivered health interventions for smoking cessation to improve outcomes for individuals with serious mental illness. However, concerns arise due to limited accessibility. Moreover, according to Agulleiro et al., there is limited evidence comparing bespoke digital interventions with generic interventions, and the authors found no studies comparing them with the usual treatment. In turn, the findings by Goldberg et al. indicated that interventions delivered through mobile phones show the potential for moderately alleviating common psychological symptoms like depression and anxiety [17]. However, the impact is generally modest, and these interventions seldom surpass other therapeutic interventions designed for the same purpose, known as specific active controls. Notably, text message-based interventions demonstrate effectiveness, especially in supporting smoking cessation. Simultaneously, research by Weisel stated that while certain trials indicated the potential of mental health-focused apps, relying on smartphone apps as independent psychological interventions cannot be endorsed, given the current state of the evidence [18].

User experience studies

In delivering any digital health solution, it is crucial to assess the efficacy and user experience to provide the highest possible quality of the intervention. One of the studies aimed at evaluating smokers' experiences related to digital health interventions for smoking cessation. In this study, the authors concluded that, among others, it is important to include simplification, personalization, different content forms, and interactivity, as well as address privacy and security issues while building apps dedicated to smoking cessation [19]. Considering user requirements for app functionality and features is vital during app design. The user needs to play a pivotal role in shaping program theories for smoking cessation interventions. Apps should incorporate a variety of essential functions and characteristics to keep users engaged. One of the systematic reviews, which focused on assessing the consistency in measuring and reporting intervention contents, channels, and dose-response outcomes in digital health interventions for smoking cessation, found that there is a lack of studies evaluating the impact of digital media interventions on smoking-related outcomes [20]. The data synthesis revealed inconsistencies in measurement and reporting across studies, indicating existing challenges in this field. While many studies prioritized reporting outcomes, a notable portion needed more clarity in measuring exposure, including both intended and actual doses. Reporting outcomes and exposures clearly and consistently is crucial to advance evidence in intervention research.

Pregnancy

A systematic review published in 2018 revealed that Text-message or computer-delivered digital interventions, especially those incorporating behavior change techniques centered on goals and planning, such as goal setting, problem-solving, and action planning, can prove effective for smoking cessation during pregnancy [21]. Nevertheless, additional research is needed to determine the potential impact of employing a greater number of behavior change techniques as opposed to fewer on the success of smoking cessation in pregnancy. Interestingly, digital health interventions for pregnant smokers have also been studied concerning continuous abstinence in late pregnancy, alongside counselling from nurses or midwives. The authors asserted that these interventions can attain continuous abstinence in late pregnancy, presenting this approach as a promising and effective tool for supporting smoking cessation interventions in pregnant women [22]. Another study assessed the eHealth intervention on different substance use among pregnant women [23]. Once again, it demonstrated that these interventions might significantly decrease substance use among the studied group of smokers and provide meaningful support for smoking cessation. Considering the complications associated with substance use, especially smoking, given the particular risks involved, it

appears worthwhile to contemplate digital interventions for supporting smoking cessation in this group.

One of the studies in the analysis evaluated the cost and cost-effectiveness of mHealth interventions supporting women during pregnancy [24]. The authors presented an analysis indicating that the reported incremental cost-effectiveness ratios were USD 2168 per disability-adjusted life year averted, USD 203.44 per woman ceasing smoking, and USD 3475 per quality-adjusted life year gained. All four full economic evaluation studies, rated as moderate to high quality, concluded that the mHealth intervention was cost-effective. Early evidence suggests that mHealth interventions may be cost-effective and relatively inexpensive. However, additional research is necessary to assess the cost-effectiveness of mHealth interventions concerning positive maternal and child health outcomes and long-term health service utilization.

Specific clinical conditions

A few systematic reviews focused on groups with cardiovascular diseases or other chronic conditions that would benefit from smoking cessation. The assessment of digital health interventions in this recipient group considered the efficacy of the intervention, adherence to medical recommendations, specific health outcomes, and cost-effectiveness in treatment. One of the studies in cardiovascular disease patients presented digital health intervention as effective in improving healthy habits such as physical activity, healthy diet, or medication adherence while lacking effectiveness in unhealthy behavioral factors such as smoking [25]. In contrast, Wongvibulsin et al. stated that the potential of digital technologies to enhance access and engagement in cardiac rehabilitation is evident, addressing challenges linked to conventional facility-based interventions [26]. Due to the common issue of low follow-up rates among cardiovascular disease patients, digital technologies provide more accessible solutions and may enhance adherence rates. Nevertheless, additional studies are required to evaluate the extent to which smoking behaviors have changed within this specific patient group.

Another study assessed the effectiveness of telemedicine-delivered psychoeducational interventions in patients with chronic diseases [27]. The research covered diverse health conditions, including smoking, chronic pain, obesity, and mental illness, employing cognitive-behavioral theory for most interventions. A majority demonstrated positive health outcomes, showing significant reductions in anxiety, pain, and depression, with varying effect sizes. Patients expressed high satisfaction, favoring lectures or self-report writings for recovery over more interactive elements. The conclusion emphasized that telemedicine patient interventions are a secure and effective approach for managing chronic diseases in adults.

Digital intervention also appeared as a potential tool in combating secondary prevention challenges in cardiovascular diseases. However, according to Kavradim et al., compared

to the generic solution, telehealth might have a greater impact on reducing waist circumference, total cholesterol, and triglyceride, improving medication adherence and physical activity while manifesting negligible effects in reducing blood pressure and smoking cessation [28].

Regarding the cost-effectiveness of digital health intervention for smoking cessation in chronic disease, one of the analyses showed that web-based counselling, SMS text messaging, and telephone counselling employed as tools for behavior change seem to be cost-effective interventions [29]. For example, an Australian study determined it was cost-effective, with an incremental cost-effectiveness ratio of USD 6123 per quality-adjusted life year. Similarly, a study in the United States revealed cost-effectiveness, reporting an incremental cost-effectiveness ratio of USD 2973 per QALY when comparing web-based and counsellor-based counselling. Another U.S. study focusing on telephone coaching for behavior change was deemed cost-effective with an incremental cost-effectiveness ratio of USD 42,457 per life-year saved for women and USD 87,300 per life-year saved for men. In contrast, a study conducted across three countries found the intervention cost-effective only in Spain, showing an incremental cost-effectiveness ratio of EUR 18,769 per QALY (USD 21,059 per QALY). At the same time, it was not cost-effective in the Netherlands or Taiwan.

Other

The significant potential of digital health intervention lies in reaching a wide range of patients and educating their caregivers. Some of the available systematic reviews aimed to assess the effectiveness of digital education among healthcare professionals delivering smoking cessation therapy. According to Semwal et al., the available evidence indicates that digital education is, at the very least, as effective as traditional learning methods in enhancing the knowledge and skills of health professionals who provide smoking cessation therapy [30]. Nevertheless, it is important to approach these conclusions cautiously due to certain limitations in the evidence base. Another study evaluated which telehealth and digital technology tools were used by community pharmacists for public health purposes [31]. It was found that telephone calls and automated telephonic prompts were the most commonly used alternative methods of communication to face-to-face discussion. It suggests that more contemporary digital solutions may not be as widespread or adequately studied.

Conclusions

Based on the received results, digital health interventions offer a variety of methods potentially impacting types of health behavior including smoking cessation. Thanks to digitalization, it is possible to reach a broader audience with education and health promotion for the general population or health care providers. It also provides a possible solution with health education, specifically in vulnerable populations or disease-specific

groups of patients. Digital health solutions might be helpful in smoking cessation therapy support for current smokers, providing many benefits for its users. However, concerns related to this process include data privacy and security, user experience, lack of high-quality studies evaluating its efficacy, and an inadequate number of studies assessing the cost-effectiveness from a public health perspective. There are potential areas that digital technologies could support in smokers and vulnerable populations. However, the level of evidence seems inadequate to establish specific recommendations.

Article information and declarations

Author contributions

Elwira Gliwska – conceptualization, data curation, methodology, project administration; resources, visualization, writing original draft, review and editing.

Marta Mańczuk – writing original draft, review and editing, conceptualization, data curation, formal analysis, supervision.

Conflict of interest

None declared

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