

Strategies to promote the use of online health applications for early detection and raising awareness of chronic diseases among members of the general public: A systematic literature review

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ABSTRACT

Introduction: Engagement is essential to achieve intended outcomes of online interventions, but achieving such engagement is a key challenge for many researchers and practitioners. This systematic literature review aims to identify strategies and tools to promote the use of online health interventions for early detection and raising awareness of chronic diseases among the public, and to investigate the evidence regarding the effectiveness of such strategies.

Materials and methods: We performed a systematic search of seven electronic databases: Embase, Medline All Ovid, Web of Science, Cochrane Central Register of Controlled Trials, PsycINFO, CINAHL and Google Scholar. The study protocol is registered in PROSPERO (CRD42020200471).

Results: The database search identified 8,526 articles, 47 were included in the review. Thirty-two studies reported strategies to promote the use of their online intervention, including online advertisements on social media (n = 17), a dating application (n = 10), and a website (n = 3). Social media were not only used for promotion of the intervention, but also as main intervention platform (n = 18). Seven studies reported traditional promotion methods such as printed advertisement and (offline) campaigns. Twenty-seven studies reported strategies to keep users engaged, including reminders (n = 12), sharing of posts on social media (n = 4), rewards (n = 3), weekly group discussions (n = 2), follow-up phone calls (n = 2), interactive games (n = 1), monthly quizzes (n = 1), links to provision of a test kit (n = 1), and a deposit-return system (n = 1).

Conclusions: No study conducted a formal evaluation of the effectiveness of the engagement strategies. Examining the effectiveness of engagement strategies is an important area for further research.

1. Introduction

The prevalence of chronic diseases and conditions is on the rise worldwide [1]. The annual number of deaths due to chronic non-communicable diseases is estimated to be 41 million people worldwide, which is equivalent to 71% of all deaths in 2016 [1]. Cardiovascular disease, cancer, respiratory disease, and diabetes are the leading causes of death from chronic non-communicable diseases [1]. Chronic diseases are but also the leading cause of disability [1]. In addition, especially in low- and middle-income countries, chronic communicable

diseases are major causes of death, with malaria being the most common cause of death worldwide, followed by HIV and tuberculosis. Early diagnosis and intensive treatment can prevent and reduce mortality and morbidity due to chronic communicable and non-communicable diseases [1]. Prevention and management of chronic communicable and non-communicable diseases are important to improve population health. Primary prevention is the most cost-effective strategy to fight these diseases [2]. Innovative strategies for health promotion and education about these diseases, to reduce mortality and morbidity and achieve global World Health Organization (WHO) targets by 2030,

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include mass media health interventions [3] and the use of information and communications technologies (ICT) in healthcare [4]. There has been a substantial increase in the number of such online health interventions in the last decade [5], since they enable providing services to many users at relatively low cost. Examples of interventions include applications for risk or health assessments for patients, disease management or self-help applications, and web-based training of health workers [6–9]. Many of these interventions have been found to be effective in positively changing health behaviours [9–12]. However, it has been observed that in trials of online health interventions, many users drop out before completion of the trial or stop using the application [7]. For example, users may stop using the application because they are no longer motivated to use the intervention, because the intervention is perceived as not creating any benefit, or because it is difficult to use [7,13,14]. This does not only happen in trials, but also when people use applications in their daily lives.

Since users must engage with the application to discover its benefits [7], effectively engaging users with online health interventions is key [10,13,14]. Engagement refers to “a quality of user experience which contains challenge, attention, aesthetic and sensory appeal, novelty or variety, perceived user control, endurance, interactivity and positive affect” [14]. Engagement is essential to achieve intended outcomes of online health interventions [7,13,14]. However, maintaining engagement remains a key challenge – it is difficult to engage people when interventions do not have human support, as is the case with online health interventions [13,14], or when interventions are not perceived as attractive[15].

Current research on online health interventions has strongly focused on determinants of behaviour change and has not addressed determinants of user engagement adequately [16]. Studies about engagement strategies of online health intervention are needed to provide further guidance on the development of effective health applications. Effective promotion and engagement strategies need to be explored and investigated to reach high functionality of online health interventions. The present study aims to identify strategies and tools to promote the use of online health applications for early detection and raising awareness of chronic diseases among the general public, and to investigate the

evidence regarding the effectiveness of such strategies.

2. Materials and methods

2.1. Registration of the review

This systematic review is registered at the PROSPERO register under registration number CRD42020200471.

2.2. Definition

For the purposes of this literature review and based on published definitions, we defined an online health intervention as “the application of both digital information and digital communication delivered largely online, aiming to improve or support the health of citizens. The online component should be essential; the intervention would not work without it” [17–19].

2.3. Conceptual framework

We developed a conceptual framework to outline all elements of an online intervention (Fig. 1). This framework includes three main elements that are relevant to our review: (1) application – device and platform, (2) engagement strategy - strategies to promote or advertise the intervention and strategies to keep users engaged, and (3) user outcomes - health outcomes and assessment of these outcomes.

2.4. Eligibility criteria

We included empirical studies that described the development and evaluation of online health interventions for self-detection, self-screening or raising awareness of chronic-communicable diseases or non-communicable diseases among people who do not know they have a condition yet. The focus of this review was on strategies or tools to promote the use of these online health interventions: strategies or tools to promote or advertise the intervention, and strategies or tools to keep people engaged with the intervention. The eligibility criteria are listed in

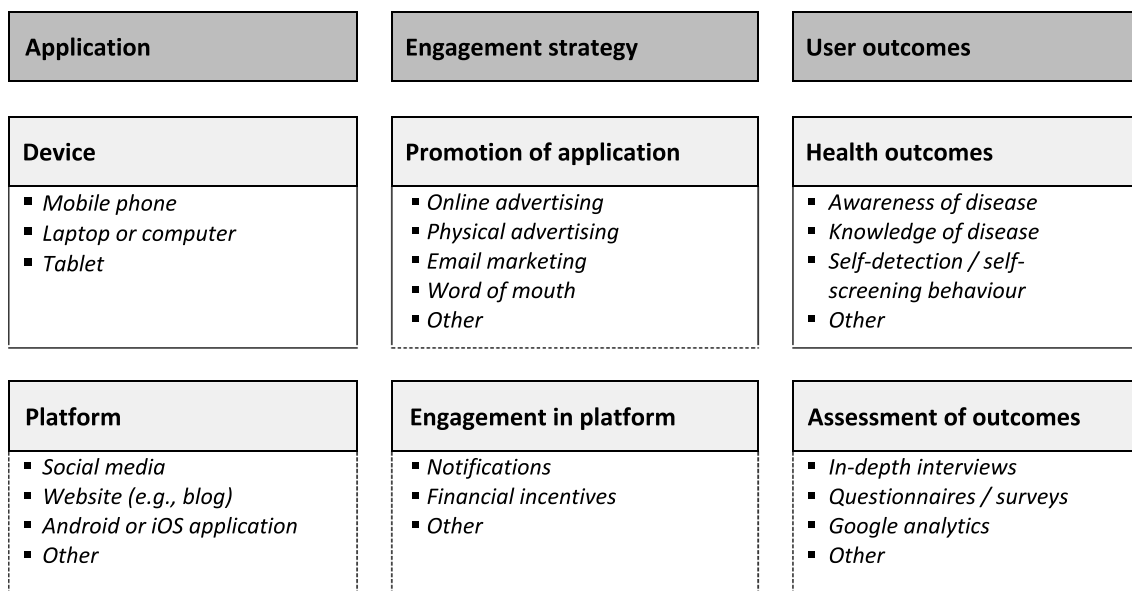


Fig. 1. Conceptual framework outlining the elements of online health interventions (applications, strategies and user outcomes) and examples of each element.

Textbox 1.

Text Box 1. Eligibility criteria for the current review.

Inclusion criteria:

Original empirical research on the development and evaluation of online health interventions

Studies that evaluate an intervention that focuses on self-detection, self-screening or raising awareness of chronic-communicable diseases or non-communicable diseases among people who do not know they have a condition yet.

Studies published in English.

Studies published in a peer-reviewed journal.

Exclusion criteria:

Studies in which the intervention is not described in sufficient detail.

Studies in which the impact of the intervention on self-detection, self-screening or awareness is not evaluated sufficiently, for example when only acceptability, design or user friendliness of the intervention is evaluated. Studies in which the intervention focuses on self-monitoring of (risk factors of)

chronic-communicable diseases or non-communicable diseases. Studies in which the target group (users)

of the intervention are health workers or people who are already aware of their condition.

Studies in which the online health intervention is only a non-essential component of a more complex programme or intervention, i.e. the intervention would also work without the online component.

2.5. Information sources and search strategy

This review complies with the Preferred Reporting Items for Systematic Reviews and

Meta-Analyses (PRISMA) guidelines [20]. The search strategy was developed in collaboration with an information specialist of the Erasmus University Medical Center (Erasmus MC) medical library. We systematically searched for empirical studies written in the English language that evaluated online health interventions for detection and awareness raising of chronic diseases among members of the general public. We performed a systematic search of seven electronic databases: Embase, Medline All Ovid, Web of Science, Cochrane Central Register of Controlled Trials, PsycINFO, CINAHL and Google Scholar. The search was conducted on June 26, 2020 and updated on June 3, 2021. The search strategy can be found in [Appendix A](#).

2.6. Study selection

Duplicates and articles published before the year 2000 were removed, because the internet was not typically used by lay people before the year 2000 [21–23]. Two reviewers (UA and ATN) independently screened titles and abstracts for eligibility, based on the criteria listed in Textbox 1. After that, they reviewed the full text of the remaining articles. The other authors (JHR, MAI and IJK) were consulted to settle disagreements about the inclusion of articles.

2.7. Data extraction

We developed a data extraction form in Microsoft Excel. The extracted data included author(s), year of publication, article title, study design, study type, study setting, study objective(s), participants, recruitment method of participants, sample size, target condition, type and description of the online health intervention, main focus of intervention (self-detection or awareness raising), description of strategies to promote or advertise the intervention, strategies to keep people engaged with the intervention, effectiveness of engagement strategies, outcome measures, outcomes reported, length of follow-up, details of control group, key conclusions, and any other results reported. Data from the first 30 articles that were screened full text were extracted and entered in Microsoft Excel by each reviewer independently. The extraction of the remaining full-text articles was completed by one author (UA) and checked by another author (ATN), who performed random checks of every 8-th article that was included. Disagreements were discussed with

the other authors (JHR, MAI and IJK) and solved.

2.8. Evaluation of the quality of studies

Engagement strategies were not the primary focus of (the evaluations conducted in) the studies included in this review. For this reason, no suitable checklists to evaluate the quality of the engagement strategies described in the studies included in this review were available. Therefore, no checklist was used to evaluate the quality of the studies. However, we did make note of potential risks of bias, such as study design, sample size, method of recruitment, randomization (if at all), and presence or absence of a control group. We have reported on the study design, randomization and use of control groups in the results section.

3. Results

A total of 8526 articles were identified through database search ([Fig. 2](#)). 3772 articles were removed before screening: 3733 duplicates and 39 articles published before 2000. After screening titles and abstracts, 4640 out of 4754 remaining studies were discarded based on the exclusion criteria. A total of 114 studies were included for full text screening. Because five records could not be retrieved, 109 articles were assessed for eligibility. A further 62 articles were excluded at this stage, for the following reasons: the effectiveness of the intervention was not sufficiently evaluated ($n = 33$), the intervention described was not an online intervention ($n = 7$), the focus of the intervention was not on self-detection or self-screening of chronic diseases ($n = 7$), target group were patients or health workers ($n = 5$), the online component was not an essential component of the intervention ($n = 4$), and ‘other reasons’ ($n = 6$). A total of 47 articles were included in the review.

3.1. General description of included articles

A total of 47 articles were included in the review. All articles were published between 2009 and 2021. Most studies were descriptive evaluation studies ($n = 25$) or randomised controlled trials ($n = 14$). The other study designs used included controlled before-after studies ($n = 5$), repeated measures study ($n = 1$), interrupted time series ($n = 1$) and a prospective cohort study ($n = 1$). The majority of the studies were quantitative ($n = 38$), a few used a mixed-methods approach ($n = 9$) and no studies used only a qualitative approach. In twenty studies, a control group was used.

Most studies were conducted in North America ($n = 17$), Europe ($n = 13$), and Southeast Asia ($n = 13$). The remaining studies were conducted in Oceania ($n = 2$) and Western Asia ($n = 1$). One study was conducted in eleven European countries, and one country each in Western Asia, Latin America and Oceania. The target conditions of the interventions included cancer ($n = 20$; including skin cancer, breast cancer, HPV/cervical cancer, colorectal cancer, oral cancer, lung cancer or simply ‘cancer’), HIV/AIDS ($n = 20$; sometimes focusing on HIV and other sexually transmitted diseases), heart disease ($n = 3$), chlamydia ($n = 2$), primary stroke ($n = 1$) and diabetes ($n = 1$). Almost all interventions focused on people at risk, for example elderly people (for cancer), young women (for HPV), or men who have sex with men (for HIV/AIDS).

Twenty studies aimed to increase awareness and knowledge about a disease in general [24–37], disease prevention [38,39] or screening [40–43]. Eighteen studies aimed to improve the user’s behaviour. Ten of them had the objective to increase the uptake of self-testing [44–53] and eight studies aimed to improve disease prevention behaviours [54–61]. Finally, eight studies specifically focused on investigating the feasibility of an online intervention [62–69].

3.2. Application: platform used

Eighteen used social media as health intervention platform

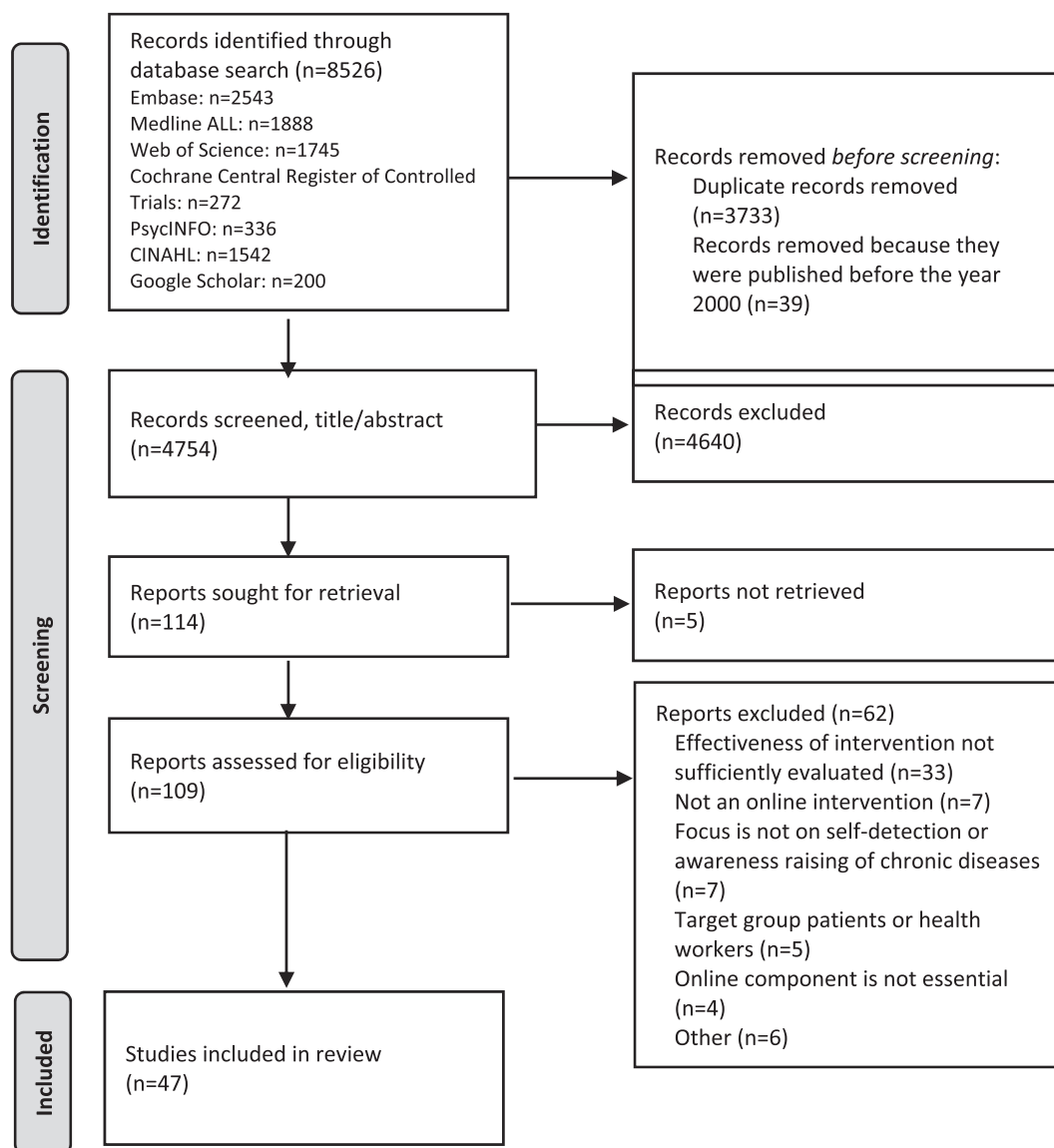


Fig. 2. PRISMA flowchart.

[24–26,33,36,37,40–42,45,48,50,56,64,67,69–71]. These studies used Facebook [24,40,42,50,64,70,71], WeChat [45,48,56,67], Snapchat [26], WhatsApp [37], and Twitter [33,70]. Furthermore, 14 studies used a smartphone application [26,27,32,34,36,37,52,53,60–63,65,66], eleven studies incorporated their intervention on a website [35,39,49–51,54–56,68], one intervention consisted of an online video [29], and one study used a mass media campaign consisting of print and online advertisements and an email blast [43]. Sometimes a combination was used, for example a website and social media [41].

3.3. Strategies or tools used to promote the use of an online health intervention

Several strategies and tools were used to promote the use of the online applications. A total of 32 studies described a strategy to promote the use of the intervention. Seventeen studies used online advertisements on social media to advertise and promote their intervention [25,35,37,39–41,44,47,50,56,60,64–68,70]. These studies used Facebook [40,44,47,50,60,64,65,68], Twitter [47], WeChat [56,66], WhatsApp [37], and Instagram [68]. Ten articles used (banner) advertisements on sexual networking or dating applications to promote

their intervention [30,45,46,51–54,64,65,68]. Furthermore, three studies promoted the intervention by online advertisement on websites [39,43,68]. Some authors used more ‘traditional’ methods to promote their intervention. For example, five studies used printed materials such as posters, handouts, magazines, and newspapers [34,44,47,49,53], and four studies held campaigns or promotion activities in public places [43,47,53,66]. Fifteen studies did not describe any promotion strategy [24,26,27,32,33,36,37,42,48,55,57,59,61–63].

Only some articles detailed how they aimed at increasing the effectiveness of their promotion strategy [25,30,35,44–46,50,52], for example using tailored messages [25], or creating ‘attractive’ advertisements by making use of certain colours and non-static media (video versus a picture) [50]. Three studies involved the target groups and/or targeted specific locations as promotion strategy [35,44,52]. For example, in one study the authors distributed printed handouts in places where the targeted group usually socializes. Furthermore, the authors cooperated with establishments that were well-known to the target group (e.g. sauna, movie theatre, cafes and bars), to promote their intervention [44]. In another study, the authors cooperated with celebrities to promote the intervention [35]. Two studies used screen notifications that were shown when opening the online application as a

strategy [30,46]. Another strategy to promote the use of interventions was crowdsourcing, through a national image contest to solicit images that promote HIV testing [45].

3.4. Effectiveness of strategies to promote the use of online interventions

Thirty articles reported some effect of their promotion strategy [25,28,30,34,35,39–41,43–47,49–54,56,58,60,64–71]. Seventeen of these 30 studies indicated the effectiveness of the promotion strategy by assessing the number of people who were reached, or the number of people who had clicked through, saw and visited the website or (social media) posts [28,30,35,39,40,43–47,49–51,56,64,66,70]. One study used the number of people exposed to the campaign as an indicator of effectiveness [43]. The number of self-tests ordered was also used to indicate effectiveness of promotion, which was mentioned in five studies [30,52,64,67,68]. Ten studies reported the number of participants enrolled in the study to indicate the effectiveness of the promotion of the intervention [25,34,45,53,54,58,60,65,69,71]. It should be noted that none of the interventions included in this review performed a formal evaluation of their promotion strategy.

3.5. Strategies to keep people engaged

Twenty-seven articles described strategies to keep users engaged with the online intervention [25,27,33–37,39–42,45,48,49,54–60,62,65–67,69,71], twenty articles did not mention any strategy [24,26,28–32,43,44,46,47,50–53,61,63,64,68,70]. Twelve studies sent (reminder) messages to encourage engagement with the intervention [27,34,35,37,40,42,45,48,49,54,56,57,59,60,62]. For example, in one study daily educational text messages (SMS) with tips to prevent coronary heart disease were sent [27]. Another engagement strategy that was used in four studies, was to ask users to post messages to encourage engagement on social media [25,33,36,69]. For example, in one study users were enabled and encouraged to share messages in their online group, other users were able to interactively comment on these messages [25]. One study provided an interactive chat room for users to send messages to their family members [69]. Another study used “Thunderclap” (an online “flash-mob” in which a common message is automatically posted on a user’s social media account) [33]. In three studies rewards (e.g. virtual credits and “prestige points”, financial compensation for spending time on a website, or gamification and nudging) were used to encourage user engagement [36,54,58]. Two studies engaged with participants by conducting weekly group discussions [37,69]. In two studies counselling was offered in follow-up phone calls [35,55].

In another study, a game was created to raise awareness about human papillomavirus and to encourage people to take action against cervical cancer. Users were also able to read story line posts or narratives on the application to help the users easily understand virus transmission and preventive measures [36]. Textual information was presented to users of the game at the beginning of each level, to increase learning and reflection of users and to encourage them to undertake preventive actions [36]. One study developed tailored content on Facebook (based on evidence from the literature about Facebook engagement), with the specific aim to maximize engagement [42]. The authors of one article indicated that they engaged with participants by providing a link to access the health intervention, for example a link to an eligibility survey for a free HIV self-test [41]. Another study engaged users by providing monthly quizzes that also offered tailored recommendations [65]. Another strategy was that individuals were asked for a deposit to order an online test kit, they received the deposit back after returning their results to the research team [67].

3.6. Effectiveness of strategies to keep people engaged

Of the 27 articles that described engagement strategies, 19 articles evaluated their effectiveness. Measurement methods included for

example percentage of participants who used the intervention [27,37,45,49,56,58–60], percentage of people who read the weekly messages [38,48], or sent the weekly messages to others [69]. One study showed the time users spent on the website [65]. Furthermore, the number of people who performed a specific activity was also used to evaluate effectiveness, for example the number of people who took a test or who requested follow-up assistance [35,40,41,67]. The percentage of the users who used an application feature was used in one study [66]. In several studies, participants received a gift card or financial compensation if they filled in baseline and/or follow-up surveys [25,27,52–54,56,57,62,69]. However, it should be noted that this was not a strategy to engage users with the online intervention, but rather a strategy to increase participation for the evaluation of the intervention. A description of all promotion and engagement strategies can be found in Table 1.

3.7. User outcomes: beyond engagement

In addition to user engagement strategies, which is the focus of this review, we have also collected data about user outcomes, such as the effectiveness of the online interventions and factors related to effective interventions. A full description can be found in Appendix B, key findings are provided below.

In 29 studies, the health intervention was found effective, for example in increasing knowledge or awareness, or changing behaviour [24–27,29,32,34–39,41,43–46,48,50,52–59,61,66]. Ability to use the intervention confidentially [35,44,46,48,53,58,68], and convenience of an online intervention versus an offline intervention [26,37,45,48,58,66] were the main factors reported to be related to successful health interventions. Promoting contact and discussions between users and other users, peers or relatives were also considered important for effectiveness [36,38,59,69]. In four studies, providing services was part of the intervention, including the provision of a free home-test [35,41,44,53,68], counselling [41,48], and medical care [41]. One study found that the use of video was more effective and appealing than printed media [29]. Social media interventions were considered more effective when they allowed users to share and comment on messages [38,58], used animations [50], or provided an award for users [36]. An abundance of information and lack of confidentiality were considered barriers when accessing or giving information on social media [24]. In addition, in three studies, the authors reported that inaccessibility of smartphones or computers and the more personal approach of printed media resulted in significantly better results in the ‘offline’ control groups, who received printed media [24,43,68]. Providing tailored messages with relevant, comprehensive, respectful, encouraging and scientifically based content, combined with attractive pictures or animations were often-reported strategies for an effective message delivery [25,32,34–37,39,41–43,46,50,54,58,60,61].

4. Discussion

This systematic review aimed to identify strategies and tools to promote the use of online health applications for early detection and raising awareness of chronic diseases among members of the general public. In addition, it aimed to systematically review the current level of evidence regarding the effectiveness of such engagement strategies. Two-third of the studies used a strategy to promote the use of their online intervention, and over half of the studies used a strategy to keep users engaged. Studies mostly promoted the intervention through online advertisements. To encourage engagement, most studies sent reminder or periodical messages. While most studies reported some effect of the promotion and engagement strategies used, in no study a formal assessment was conducted.

Findings from the present study indicate that online health interventions can be effective in improving awareness and facilitating behaviour change. Online health interventions were previously found

Table 1
Description of promotion and engagement strategies of the articles included in this review.

Author and year of publication	Study design ^a	Type of online intervention (application)	Strategy to promote (advertise) the online intervention	Effectiveness of strategy to promote (advertise)	Strategy to engage (keep using) the online application	Effectiveness of strategy to engage (keep using)
Koivogui, 2020 [40]	Descriptive evaluation study	Social media - electronic awareness messages on Facebook	Targeted Facebook advertisements (advertisements were targeted and matched the optimal content per participant, created using artificial intelligence algorithms); of the 75,380 people in the target area, 39,900 (53%) people were reached/viewed a promotional message	effective	The electronic awareness messages on Facebook resulted in 9,200 people (23% of the people who viewed a promotional message) watching at least one video/Facebook message. Of them, 4,450 (48%) people visited a web page to learn more about the program, 298 people applied for a test kit.	effective
Walter, 2020 [62]	RCT	Smartphone application	not reported	not reported	Monthly reminders (in the smartphone application); 51 participants (21%) had consultations regarding skin changes during the 12 months of follow-up, and 157 participants (66%) responded to at least 1 follow-up questionnaire	effective
Johnson, 2020 [41]	Descriptive evaluation study	Social media and website	Targeted social media campaign advertisements; 6,190 individuals completed the eligibility survey, 3,197 (52%) were eligible and received a coupon. Of the eligible, 2,022 (63%) redeemed coupons for HIV self-testing kit.	effective	Social media advertisements and images that redirected to an eligibility survey for a free HIV self-test; 922 of 2,022 participants who redeemed the coupon (83%) had used the HIVST for themselves, 98% were willing to refer the test kit to a friend, and 761 participants requested follow-up assistance or service	effective
Gajda, 2020 [57]	RCT	Website	not reported	not reported	Reminders (what kind of reminders is unclear), the dropout rate was 59%	unclear
Agha-mir-Salim, 2019 [24]	RCT	Social media - Facebook page	not reported	not reported	not reported	not reported
Lyson, 2018 [25]	Controlled before-after study	Online social media platform (to share and discuss brief messages)	Targeted advertisements/posts on popular social media sites and targeted email lists; of the people who completed the eligibility screening, 862 (88%) were both eligible and consented to participate. Of the 862 who consented to participate, 782 (91%) participants enrolled in the study.	effective	Ability to interactively send, share and comment on messages in an online group; 569 participants completed the post survey (73% completion rate)	unclear
De Boni, 2019 [44]	Descriptive evaluation study	Website	Printed handouts distributed via in-person outreach events; partnerships with establishments the target group often visits; and virtual messages disseminated through a Facebook page and gay online sites - the website was viewed 67,225 times by 17,786 unique visitors	effective	not reported	not reported
Cheng, 2019 [58]	RCT	Website	Recruitment advertisements were placed on the web portal and posted at the top of the website bulletin board system; 1,608 people completed the consent form, 1,100 (68%) people were eligible and randomized.	effective	Some information was sent directly to the participants' e-mail address and participants received virtual rewards when completing both the baseline and follow-up surveys (virtual credits and 'prestige points'); 550 people were allocated to the intervention group, 49 people were lost to follow-up (9%; lost to follow-up was 12% in the control group)	effective
Bowen, 2019 [59]	RCT	Website	not reported	not reported	Email reminders (every three months); one-year follow-up data were collected from 89% of the first-degree relatives (of cancer patients) who participated	effective
			not reported	not reported		effective

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Table 1 (continued)

Author and year of publication	Study design ^a	Type of online intervention (application)	Strategy to promote (advertise) the online intervention	Effectiveness of strategy to promote (advertise)	Strategy to engage (keep using) the online application	Effectiveness of strategy to engage (keep using)
Klippert, 2018 [42]	Descriptive evaluation study	Social media - Facebook (page) campaign			The Facebook post content was tailored using evidence from the literature about Facebook engagement and mammography message tailoring to maximize engagement; there were 1,189 reactions to the campaign, 2,043 clicks on the campaign posts, posts were shared 204 times, the campaign received 43 comments, and the health department's Facebook Page received 29 additional likes during the campaign.	
Krishnamurthi, 2018 [63]	RCT	Smartphone application - Stroke Riskometer App	not reported	not reported	not reported	not reported
Tang, 2018 [45]	RCT	Social media application - WeChat	Participants were then recruited through a social networking mobile phone application (Blued) by sending a survey invitation to users, the study link was clicked 39,764 times, 23,571 (60%) read the informed consent form of which 21,187 (90%) people did not meet eligibility requirements. Finally, 1,381 participants enrolled (58% of the eligible participants).	effective	The promotional images were disseminated by WeChat biweekly, 1,007 people participated in the final follow-up (73% of total participants who enrolled)	effective
Alanzi, 2018 [26]	Controlled before-after study	Smartphone application - SnapChat	not reported	not reported	not reported	not reported
Ribeiro, 2017 [60]	Descriptive evaluation study	Smartphone application	Recruitment was done through e-mail (University mailing list) and the study announcement was posted on a Facebook page, 53 individuals answered the initial recruitment survey, the final sample size was 32 (60%).	effective	Daily tailored push notification messages with a prompt to answer a behaviour question; during the 28-day trial period, there were 13 (41%) active users per day. The dropout rate was high, with only 6 users (19%) completing the 28-day trial period of the app.	effective
[27]	RCT	Smartphone application - Care4Heart	not reported	not reported	A daily short message service (SMS) offering healthy tips and prevention; one participant was lost to follow-up (3%).	effective
Elliot, 2016 [64]	Descriptive evaluation study	Social media - Gaydar, Grindr, Recon and Facebook	Promotional banners and intermittent campaigns on social media websites (including Gaydar, Grindr, Recon and Facebook); 66,579 individuals users visited the website to order a free postal HIV home sampling kit.	effective	not reported	not reported
Huang, 2016 [46]	Descriptive evaluation study	Website	Advertisements on a smartphone social networking application (Grindr) with a link directing people to a website; 62,820 people saw the advertisement, the study website received 11,939 unique visitors, the click-through rate of the advertisements was 3%.	effective	not reported	not reported
Neufingerl, 2014 [28]	Descriptive evaluation study	Website	Advertisements on butter packages, television, newspapers, in store applications, "etc"; 2,744,091 Heart Age users were included in the data analysis (3,374,769 people used the Heart Age tool available via a free open access website, between July 2009 and December 2011)	effective	not reported	not reported
Mann, 2013 [47]		Website		effective	not reported	not reported

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Table 1 (continued)

Author and year of publication	Study design ^a	Type of online intervention (application)	Strategy to promote (advertise) the online intervention	Effectiveness of strategy to promote (advertise)	Strategy to engage (keep using) the online application	Effectiveness of strategy to engage (keep using)
	Descriptive evaluation study		Promotion on Facebook and Twitter pages, and traditional advertising methods including transit advertising, print posters, business cards, and condom wallets; 13,385 website visits, 82% of them (n = 11,050) were unique visitors.			
Idriss, 2009 [29]	RCT	Online video	Advertisements placed online and on flyers (no more details are provided), then participants were given instruction on how to access the intervention; effectiveness is unclear, 86 people were assessed for eligibility and 78 (91%) included in the study	unclear	not reported	not reported
Rosengren, 2020 [30]	Descriptive evaluation study	Website	Daily continual banner advertisements and weekly full screen notifications on an application (Grindr); the website received 4389 unique visitors, with an average of nearly 150 visits per day. This resulted in 333 (8%) unique test requests	effective	not reported	not reported
Patel, 2016 [31]	Descriptive evaluation study	Website	Media coverage and press releases (exact strategy unclear), effectiveness unclear	not reported	not reported	not reported
Yaacob, 2020 [32]	Controlled before-after study	Smartphone application -ColorApp	not reported	not reported	not reported	not reported
Gough, 2017 [33]	Interrupted time series	Social media - Twitter (using a charity's Twitter account to disseminate messages)	not reported	not reported	Thunderclap (a Web-based "flash-mob" of messages involving users to permit their social media accounts to automatically post a common message) and paid-for promoted posts on Twitter to increase the number of people who saw the messages; post engagements reached 11,213, and there was a total of 1211 retweets (of these 92 retweets were part of the Thunderclap). The study did not find value in the use of paid-for, promoted tweets.	effective
Jiang, 2019 [34]	Repeated measures study	Smartphone application - Care4Heart	Poster advertisements (not further details are provided); the authors aimed to include 120 people, eventually 160 people were recruited (133%).	effective	Daily SMS reminders providing healthy tips for disease prevention; effectiveness is unclear	unclear
Zhu, 2019 [48]	RCT	Social media application - WeChat	not reported	not reported	Two new additional (contextualised) messages were added to the application weekly; 63 of 79 (80%) of the messages were read by > 20% of the participants and 12 of 79 messages (15%) of the messages were seen by > 50% of the participants	effective
Anand, 2017 [35]	Descriptive evaluation study	Website	Tailored social media promotion including cooperation with celebrities and relevant community members; 272,568 people were reached online via social media promotions.	effective	Once website users have made an initial appointment, they receive a confirmation email and a reminder email one day prior to the check-in date; 325 (76.5%) users checked-in at one of the four study clinics and received HIV testing	effective
Hoa Lam, 2017 [49]	Descriptive evaluation study	Website	The study received broad nationwide media coverage on approximately 20 media outlets, including radio, TV, online news and magazines and print newspapers, in addition,	effective	A reminder eight weeks after the initial invitation; an additional 2,330 participants (10%) responded after receiving a reminder.	effective

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Table 1 (continued)

Author and year of publication	Study design ^a	Type of online intervention (application)	Strategy to promote (advertise) the online intervention	Effectiveness of strategy to promote (advertise)	Strategy to engage (keep using) the online application	Effectiveness of strategy to engage (keep using)
Ruiz-López, 2019 [36]	Descriptive evaluation study	Smartphone application (game) - FightHPV	participants received an invitation letter; 5,154 (22%) participants responded after the first invitation. not reported	not reported	Gamification and nudging, e.g. sound and character animation to encourage players to retry the level in case of failure, ranking of scores in leader boards, ability to share scores and compete with other users, achievements, and sharing on social media was incorporated; effectiveness is unclear	unclear
Nadarzynsky, 2019 [50]	Descriptive evaluation study	Social media - Facebook, and website	The advertisement on Facebook (an animation that lasted 10 s on a loop) reached 40,347 women and 37,292 men. 1400 Women (3%) and 1413 men (4%) interacted with the advertisement. The website received 2,825 visits. not reported	effective	not reported	not reported
Leung, 2018 [61]	Other design – prospective cohort design	Smartphone application - Diabetes Risk Score app	not reported	not reported	not reported	not reported
Sullivan, 2017 [65]	Descriptive evaluation study	Smartphone application	Advertisements on Facebook and a social/sexual networking mobile phone app; 309 people were eligible to participate, study enrolment was 121 (39%).	effective	Monthly risk assessment quizzes that offered tailored prevention related recommendations; over four months, participants used the app on average for 17 min 40 s and made 133 clicks. On average, participants used the app on a mean of 4.9 days.	effective
Combs, 2019 [51]	Descriptive evaluation study	Website	Push messages and banner ads to the users of dating apps; during the period the website was advertised, the website had 142,327 visits and 282,636 page views. not reported	effective	not reported	not reported
Pramod Nayak, 2017 [37]	RCT	Smartphone application (messages) - WhatsApp	not reported	not reported	Daily WhatsApp messages (text, pictures, and videos) sent in a WhatsApp-based anonymous chat room; 76 people participated in the WhatsApp intervention, 4 were lost to follow-up (5%).	effective
Yan, 2020 [66]	Descriptive evaluation study	Smartphone application	Promotion in online platforms (WeChat, QQ, and Weibo) and offline venues (clinic, parks, and bars); the app reached 3186 people (n = 678 or 21% interacted with/used the app).	effective	Weekly health education (disseminated in the application) with disease information and a partner notification module; 678 people (21%) interacted with/used the app, of these people 254 (38%) had used the partner notification feature.	effective
Wallington, 2018 [43]	Descriptive evaluation study	A mass media campaign (print and online advertisements)	The mass media campaign included print ads (in metro stations, buses, and the newspaper), online ads (on a TV network website) and an email blast through the newspaper; the campaign generated 9,479,386 impressions, of which 705,206 (7%) through the online advertisements, the click-through rate of the website advertisements was 0.3%.	effective	not reported	not reported
Wu, 2020 [67]	Descriptive evaluation study	Social media application - WeChat	Banner advertisements on a social media platform; 371 men applied for test kits.	effective	A deposit - test kits were mailed after receiving a deposit, the deposit was returned after users uploaded a photograph of their results; the overall return rate was 99% (1150 kits were ordered, 1141 tests were followed by a photograph).	effective
		Website		effective	not reported	not reported

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Table 1 (continued)

Author and year of publication	Study design ^a	Type of online intervention (application)	Strategy to promote (advertise) the online intervention	Effectiveness of strategy to promote (advertise)	Strategy to engage (keep using) the online application	Effectiveness of strategy to engage (keep using)
Menza, 2021 [68]	Descriptive evaluation study		Banner advertisements on a sexual networking app (Grindr) and posts on community HIV prevention partner Facebook and Instagram pages and websites; 233 ordered test kits (in addition, within 24 h of the launch, the authors received orders for 109 (73%) of the 150 kits initially allotted to the program, the kit allotment was later increased).			
Duong, 2021 [69]	Controlled before-after study	Social media (family group chat) - Let's Chat	Participants were recruited via an emailed advertisement; ten families (n = 41) participated in the intervention.	effective	One participant was responsible for facilitating the group chat, this person was prompted to introduce, discuss and share certain topics/information with their family members; most family group chats (n = 8, 80%) were highly or moderately engaged with each week's conversation, the highest weekly number of messages sent was 46.	effective
Sundstrom, 2021 [70]	Descriptive evaluation study	Social media campaign (Facebook and Twitter)	The social media advertisements included prompts to "Like"/"Follow" social media platforms; the campaign resulted in over 370,000 total impressions, reached over 33,000 individuals, and culminated with over 1122 followers.	effective	not reported	not reported
Yun, 2021 [56]	RCT	Social media application - WeChat, and website	Participants received a push notification with a QR code over WeChat; after three months of intervention, the percentage of page visit was stable (68%, 52%, and 65% respectively), while in the control group the percentage declined (60%, 39%, and 18% respectively)	effective	Reminders with information related to the intervention were sent every four weeks; after three months of follow-up, the clinical trial retention were 90% (86/96) for the intervention group and 85% (82/96) for the control group, no participant discontinued the intervention.	effective
Brandt, 2020 [71]	Descriptive evaluation study	Social media - Facebook	Participants were invited through email using a university mailing list; 58 people participated.	effective	Weekly electronic newsletters and interactive Facebook posts (study investigators also provided answers to questions on Facebook); $\geq 90\%$ of participants opened the weekly newsletter, in addition, participants made 906 comments and likes during the intervention period.	effective
Balán, 2021 [52]	Descriptive evaluation study	Smartphone application - SMARTtest app	Exact promotion strategy is unclear, but was done on via geospatial sexual networking applications, online forums (Craigslist, etc.), and in-person (LGBT Center, etc.); 37 people used the self-test	effective	not reported	not reported
Biello, 2021 [53]	Descriptive evaluation study	Smartphone application - LYNX and MyChoices	Web-based and social media strategies (e.g., Craigslist, social networking ads, and gay sexual networking mobile apps), posters, flyers, and palm cards, direct outreach at local venues frequented by YMSM, clinic; 80 participants were enrolled and randomized to the intervention arm, 67 (84%) completed the 3-month follow up assessment and 63 (79%) completed the 6-month follow up assessment.	effective	not reported	not reported
Weitzman, 2020 [54]	Controlled before-after study	Website	Printed advertisements (through collaborating health and social service agencies) and	effective	Twice-weekly e-mail/texts with evidence-based activities for promoting happiness and	unclear

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Table 1 (continued)

Author and year of publication	Study design ^a	Type of online intervention (application)	Strategy to promote (advertise) the online intervention	Effectiveness of strategy to promote (advertise)	Strategy to engage (keep using) the online application	Effectiveness of strategy to engage (keep using)
			online advertisements (through Craigslist); 451 people were assessed for eligibility, 331 (73%) were randomized.		resilience, and participants received financial compensation for spending time on the website (\$1.00 for every 5 min) and for each text they received (25 cents per text); effectiveness is unclear, however, 62 of the 158 people (39%) in the intervention group did not fill in the post questionnaire.	
Paskett, 2020 [55]	RCT	Website	not reported	not reported	Periodical phone call for follow-up status, counselling and assistance; a total of 458 (89%) participants spoke with the navigator (8 refused and 49 were unable to be contacted by the navigator).	unclear
Mueller, 2019 [39]	RCT	Website	Promoted through a (university) mailing lists, social media, advertising pages (e.g., gumtree), various websites (e.g., a website for senior citizens) and Google AdWord (which allowed the website to be displayed near the top of Google search results); there were 2,463 website visitors, the majority of them (76%) left the page without any further interactions, 24% (~614 users) performed interactions to website (for example click on the "about" link or the "consent" button).	effective	None, however, the website was tailored (based on prior research, involvement from target group and constructs from the theory of planned behaviour) and designed to take only a short time to visit/complete; effectiveness is unclear.	unclear

^a RCT: Randomized Controlled Trial.

highly successful to establish behaviour change [72]. Authors of previous studies emphasized that participants are able to obtain encouragement and social support through social media and the internet [72,73]. Participants can receive relevant information such as email addresses of health providers, as well as communicate with them in a way similar to traditional in-person meetings [72]. Despite this, one randomised controlled trial found that online platforms such as Facebook were not better than the printed version of a leaflet in terms of increasing health knowledge of young adults in the UK [24]. Social media contained an abundance of information from various sources, and it was found to lack credibility. The probability of the main information being seen may be lower, and the attention of the readers could be distracted. Additionally, the leaflet was delivered personally with the participant's name on the envelope. This likely directly grasped the participant's attention [24]. These findings suggest that while social media can be effective in behaviour change, there are also factors (for example distractions and quantity of information) that can reduce the effectiveness and of social media, that should receive specific attention when designing interventions.

Studies have found that online health promotion has great potential, for instance, such interventions can improve engagement of users and can easily be incorporated into people's daily lives [74,75]. A systematic review by Maher et al. [10] about the effectiveness of online health intervention on health behaviour change such as weight loss, physical activity, and dietary awareness, found that interventions that encouraged social interaction had a higher engagement and user satisfaction than 'non-social' interventions [76-78]. One study mentioned that participants could generate comments on the information of other participants' health behaviour-related activity [78]. This allowed them to be open to reciprocity to others and sometimes could result on a

provocative element (for example participants congratulated someone of being the number one in the ranking of walk steps number) [78].

Reminder messages were reported mostly in our review as user engagement strategy. Studies have found that electronic reminders such as SMS and audio/visual reminders were effective in modifying patients' adherence to an intended health behaviour [79]. Users of all ages may benefit from a reminder as they may forget to perform an activity because of busy lives in youth or memory problems in elderly persons [79]. Furthermore, an interactive reminder system was shown to be acceptable for tuberculosis patients because it motivated and shaped feelings that they were cared for [80].

In the present review, delivering customized or tailored messages was found to be an acceptable and often-used strategy to keep people engaged with an online intervention. Given that web-based health content may be redundant and repetitive, delivering a tailored message based on recipients' needs, interests, and concerns can ensure the messages are appropriate for a specific target group [81,82]. A literature review about tailored messages for health promotion and behaviour change [82], found that tailored messages can improve physical activity in society. In addition, a Delphi study found that tailored feedback or reminder messages were associated with continuation of internet-delivered interventions [83]. The effectiveness of tailored message can be increased when they are developed using a theoretical framework, for example the transtheoretical model. Yap & Davis found that often multiple theories were used in studies, but that the authors of these studies provided little description of how they had used these theories [82]. Even though the exact process of the tailored message effect is unclear, it is generally thought that motivation and health behaviour are more likely to improve when personally relevant information is included in the message [84]. Besides tailored messaging, a study that

investigated the reason people visit and utilize internet-delivered behaviour change interventions, found that appearance, concise and easy to understand text and a focus on people's motivation for potential behaviour change can also promote the use of online interventions [85].

The present review found that online services such as self-testing, that can be used anonymously, are successful for stigmatised conditions such as for example HIV/AIDs. Using services like these online as opposed to going to a facility, can prevent public stigma, embarrassment, or judgement from others. By doing a self-test, people do not need to spent time to go to the health centre, e.g. taking a day off of work is not required [68]. Besides being comfortable taking tests in their own home, a home test kit was also found acceptable, especially when clear instructions on how to use them are given [53]. Users do not have to test in public places and can remain anonymous, so their privacy is protected [53]. In public places, patients often fear to face and face stigma – a private service is often preferred over a public clinic or community-based site [35]. Even though at the beginning of a study, participants had low trust on the results of the self-test kit, participants could finally put their trust on the kit after receiving messages as part of the online health intervention [48]. Thus, we importantly addressed that developing access to safe, reliable, affordable, accurate, and importantly convenient and confidential self-test kit is important to build trust of users and to increase the self-testing behaviour [48,86]. Online services for stigmatised conditions can empower people to manage their condition.

Social media may have a strong impact on health behaviour as it involves the social network of users (e.g. friends and relatives). A study by Ellison [87] found that people commonly used Facebook to interact and share information with people that they already knew offline rather than with people whom they did not know. This is not surprising, as Facebook comprises a network of friends that need to be 'approved' before they are added to the network. Another study found that Wikipedia, online forums, and message boards were the major sources of online health information for 34% of adults in America to obtain health and wellness information [88]. A qualitative study by Brouwers and colleagues [85] found that counselling and peer support options, such as chat rooms and forums, are related to more time spent on intervention websites. The presence of family, friends, and relatives who are supportive in life, full of respect and encouraging was endorsed to be a useful strategy in terms of the participants' decision making [89]. Therefore, it is important to consider the role of close relatives and other support networks in the use of online interventions.

To our knowledge, this current systematic review is a pioneer study about the effectiveness of engagement strategies of online health interventions for early detection and raising awareness of chronic diseases among the general public. We included trial and evaluation studies of online health interventions and identified several strategies of effective health interventions to prevent chronic diseases and of effective engagement strategies. All studies included in this review primarily focused on the effect evaluation of online interventions, instead of on evaluation of engagement strategies. It is important to note that although many engagement strategies have been described, formal evaluation is limited. Examining the effectiveness of engagement strategies is an important area for further research.

5. Conclusions

Findings from the present study suggest that varied engagement strategies are applied, and are necessary to improve exposure to online health interventions and to improve the overall impact of such interventions. The scanty evidence on effectiveness of engagement strategies suggests that online advertisements and reminder messages have the potential to improve user engagement. We found that the evaluation of engagement strategies of online interventions is insufficient. All studies included in this review primarily focused on the effect evaluation of online interventions, instead of an evaluation of engagement

strategies. Developing an online health intervention with engagement strategy can be promising. Examining the effectiveness of engagement strategies is an important area for further research and for an effective online health application or intervention.

Summary table

What was already known on the topic	<ul style="list-style-type: none"> • There has been a substantial increase in the number of online health interventions in the last decade, many of these interventions have been found to be effective in positively changing health behaviours • User engagement is essential to achieve intended outcomes of online interventions, however, maintaining engagement remains a key challenge
What this study added to our knowledge	<ul style="list-style-type: none"> • Varied engagement strategies are applied, and are necessary to improve exposure to online health interventions and to improve the overall impact of such interventions • The scanty evidence on effectiveness of engagement strategies suggests that online advertisements and reminder messages have the potential to improve user engagement • The evaluation of engagement strategies of online interventions is insufficient, this is an important area for further research

CRedit authorship contribution statement

Ulfah Abqari: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Anna T. van 't Noordende:** Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Jan Hendrik Richardus:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Mohammad Atoillah Isfandiari:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Ida J. Korfage:** Conceptualization, Methodology, Supervision, Resources, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijmedinf.2022.104737>.

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