Assessing Digital Support for Smoking Cessation*

Alessio De Santo[1] and Adrian Holzer[1]

University of Neuchâtel, Neuchâtel, Switzerland
{alessio.desanto,adrian.holzer}@unine.ch

Abstract. Tobacco still kills more than 7 million people each year. Research points to several evidence-based interventions to support smoking cessation which, if applied widely, could considerably reduce premature deaths. There is a huge range of mobile apps targeting this concern, which could potentially be powerful catalysts to provide this support. Yet it is unclear how much of their design is evidence-based and how effective they are. To address this issue, this paper provides an analysis of 99 popular smoking cessation apps. The results show that only two apps come from a credible source, provide support for user engagement through advanced motivational affordances and have been evaluated for efficacy.

Keywords: smoking cessation · smartphone apps · digital support · mHealth · user engagement · content analysis

1 Introduction

Do you think smoking is a public health concern of the past? Think again. According to the World Health Organization (WHO) tobacco use is still the single biggest preventable cause of death in the world today [30]. Tobacco kills 7 million people a year, which could potentially increase to more than 8 million by 2030 if left unchecked [30]. Most smokers, aware of the dangers of tobacco, would like to quit but they need help [30]. Simple behavioral change interventions can considerably reduce premature deaths of tobacco users [29].

Digital resouces are increasingly available to support individuals in adopting healthier behaviors [13, 18]. An ever-increasing global adoption of mobile devices, such as smartphones and connected devices, has spurred rapid growth in the field of electronic health. New technologies are giving individuals the potential to engage more fully in their healthcare decision-making, opening possibilities to improve health outcomes [8, 17].

Face-to-face counseling is the most universally effective means of helping people quit [8] but, currently, participation rates in these programs are low [15] and they are not affordable globally [28]. Digital solutions to support smoking cessation can provide some advantages over traditional face-to-face methods, for

* Supported by the Swiss Learning Health System project.

example in terms of scalability and user proximity. Participation rates could be improved by leveraging features such as real-time data collection, feedback and low-cost dissemination [16].

Current literature establishes mobile phones as potentially useful in helping smokers quit [8]; however, among the thousands of mobile applications (apps) it is unclear how much of their design is evidence-based and how effective their use is. To address this issue, this paper provides a critical analysis of the most popular smoking cessation apps and identifies open research gaps and future promising research avenues.

2 Smoking Cessation – What Works

Government organizations, medical societies, research networks and research centers establish guidelines to provide a comprehensive review of the scientific evidence for treating tobacco use and dependence [9]. A review of 26 current guidelines allowed us to identify globally recommended smoking cessation interventions, with four of them providing strong evidence of efficacy: *brief advice*, *behavioral support*, *pharmacotherapy* and *abstinence evaluation* [27].

- *Brief advice.* Brief advice is 5 to 10 minutes of advice to encourage smokers to improve their health by quitting their smoking habit, primarily by triggering a cessation attempt. Some frameworks, such as the 5A's and the ABC framework, provide a structure for providing brief advice. The 5A's stands for *Ask*, *Assess*, *Advise*, *Assist* and *Arrange* a follow-up. The ABC stands for: (A) *Ask* all people about their smoking status, (B) provide *Brief advice* to stop smoking to all people who smoke, (C) make an offer of evidence-based *Cessation treatment*.
- *Behavioral support.* Often when smokers try to quit, they need behavioral support to avoid relapses. There are three main methods of providing behavioral support: (1) self-help material, (2) peer group meetings, (3) health professional counseling. The first method, self-help information, can support patients without outside help. When self-help is personalized it is even more effective [19]. In the second method, peers meet regularly and provide each other with support and encouragement. Compared to self-help, peer group support is more effective in helping smokers quit [19, 20]. In the third method, health professionals provide individual counseling through face-to-face appointments. This patient-centered approach is the most effective. Providing multiple and longer sessions also increases the effectiveness [19].
- *Pharmacotherapy.* Guidelines suggest the use of pharmacotherapy such as nicotine replacement therapy, bupropion and varenicline to assist patients with nicotine withdrawal [27]. In situations such as abruptly quitting smoking, a combination of behavioral support and pharmacotherapy is recommended [19].
- *Abstinence evaluation.* Guidelines suggest that abstinence evaluation confirmed by objective measurements is providing strong evidence in smoking

cessation programs [27]. Measurement forms include various techniques such as tracking systems, biochemical markers and clinical tests. Even though tracking systems can in principle be bypassed, research suggests that increasing smoking awareness and providing tools such as goal setting [11] and tailored feedback [6] helps smokers to quit. These tools are important, since smokers are generally unaware of their daily smoking patterns [7].

3 Smoking Cessation Apps – What Research Says

Early attempts to assess mobile support for smoking cessation have primarily rated apps according to their adherence to smoking cessation treatment guidelines [1–3, 5, 10]. Overall, apps identified by Abroms et al., [2, 1] presented low adherence to established US guidelines for smoking cessation. The recommendation of Abroms et al., [1, 2], for future development, was to greatly adhere to such guidelines and other evidence-based practices. Bennett et al., [3] provided conclusions consistent with those of Abroms et al., [1, 2]. These US findings were echoed around the world, as smoking cessation apps also have low levels of adherence to Chinese [5] and Australian smoking cessation treatment guidelines [25].

Research suggests that the more a smoking cessation app is opened and accessed, the more likely the user is to quit smoking [4]. Thus, factors that might influence routine use are particularly important to consider for mobile app interventions, as 26% of apps are discontinued after first use, and 74% are used no more than 10 times [12]. *User engagement* and *source credibility* are two dimensions that appear to be important aspects of mHealth routine use [12, 14, 23].

In this paper, we build on these findings and critically assess existing digital smoking support solutions not only on their adherence to guidelines, but also on how their design encourages user engagement, and on their source credibility. The source credibility of an app relates to the emitting authority and significantly influences mHealth routine use [14]. *Competence* and *trustworthiness* are the main subdimensions of source credibility [24]. Competence refers to expertise, while trustworthiness is a function of the perceived character and integrity of the source. An app's emitting authority is not always mentioned, making the evaluation of its competence and trustworthiness difficult. Note, however, that source credibility refers to a user's perception of the credibility of an emitting authority, reflecting nothing about the app itself.

User engagement can be measured through the activity of a user of the app (number of visits, time spent, actions performed, etc.). It can be enhanced through motivational affordances, i.e. design features that trigger psychological levers such as intrinsic motivation, sociometric status and reciprocity [23]. Suh et al., [23] identified four types of motivational affordance, leading people to be better engaged in an activity:

- *Rewards.* By obtaining points as a pay-off for completing pre-designed tasks, users reach levels or milestones rewarded by virtual badges and trophies demonstrating their accomplishments.

– *Competition.* Users have the opportunity to compare with, and compete against, other people through components such as leaderboards, permitting them to visualize their standing against other users or friends.
– *Self-expression.* Personal identities can be created by users, through avatars and emoticons, enabling them to express their emotions.
– *Altruism.* Points and virtual goods can be exchanged between users.

Figure 1 provides an overview of the three-dimensional perspective for building an evidence-based app that will potentially encourage user engagement and routine use.

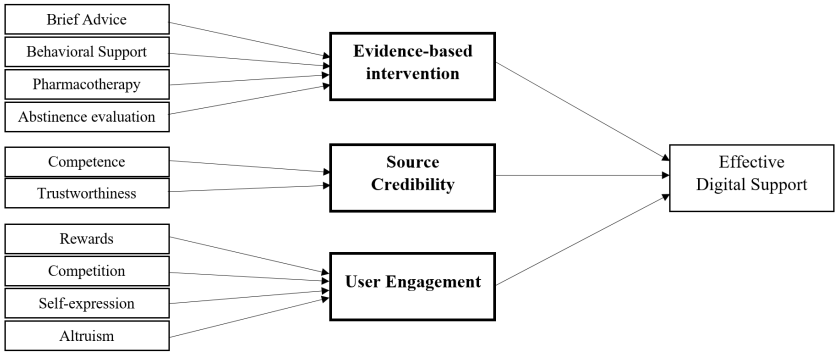

Fig. 1: Research three-dimensional perspective.

4 App Landscape – What Currently Exists

To identify current practices, we collected a subset of the most popular apps and reviewed them on: *evidence-based* practice adherence, *source credibility* and motivational affordance that encourages *user engagement*. We also investigated whether apps were *validated* through evaluation studies. The app collection was conducted through the Explorer research tool provided by 42Matters (https://42matters.com/), on 19 November 2018. The following search terms were used to perform the queries on the title and description of the apps: *quit smoking*, *smoking cessation* and *stop smoking*. For each search term, the 40 most popular apps were retrieved on the number of downloads and on a rating basis, resulting in 120 Android apps and 120 iOS apps. Duplicate apps were removed, resulting in 92 iOS apps, 78 Android apps and 18 apps available on both platforms. Inclusion and exclusion criteria, as presented in Table 1, were applied to exclusively select smoking cessation apps. Figure 2 depicts the results of the process. The remaining 99 apps were then manually coded by parsing the app description, screenshots and website (where available).

Table 1: Inclusion and exclusion criteria.

Inclusion criteria
Apple iOS and Google Android app
only apps available in the English language
only apps published in the Apple App Store or the Google Play Store
only apps containing in their description or title "quit smoking", "smoking cessation" or "stop smoking"
Exclusion criteria
unrelated app
general health and wellbeing app
exact duplicates between different app stores

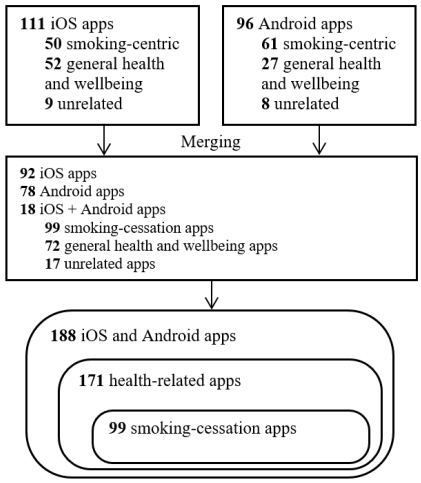

Fig. 2: Procedure for our smoking cessation app sample selection.

4.1 Adherence to Evidence-Based Practices

As a first dimension of our review, apps were coded in respect of adherence to evidence-based practices: *brief advice*, *behavioral support*, *pharmacotherapy* and *abstinence evaluation*. The coding process was inspired by grounded theories and open coding techniques [22, 21], making the categories emerge by their proximity.

For the *brief advice* subdimension, we coded whenever apps provided smoking cessation *tips*, *pieces of advice* or *recommendations*. Apps' descriptions and screenshots were parsed, looking for this specific content addressed to smokers and representing brief advice interventions. Brief advice in a smoking cessation app can, for instance, be "Rejecting is easier if you do it with someone who has the same problem and understands you completely. [...]" (Ex Smoker, Sopharma AD), or when a smoker is reporting a craving, tips such as "drink something (water, juice)", "eat some fruit" or "brush your teeth" (Stop-tobacco, Université de Genève).

Concerning the *behavioral support* subdimension, we identified three different levels of support: (1) apps providing *self-help* support with cessation facts, (2) apps having a *social* dimension and (3) apps providing a guided smoking cessation *program*. Self-help cessation facts, are usually related to monitoring information and provide smokers with statistics about their behavior. For instance, apps can inform about the time elapsed since their last cigarette, the number of cigarettes smoked daily, or empowering facts triggered after quitting, such as "You have no more physical dependence on nicotine" (Qwit, Team Geny) or "Taste and smell senses regained" (Smoke – quit, NikNormSoft). Apps providing peer group support offer features such as community chat, permitting sharing and the discovery of peer experience, but also features allowing smokers to share their progress and achievements about smoking cessation on social networks such as Facebook and Twitter. Apps can also rely on specific programs, conducting smokers through the use of the app. Programs can have different formats, such as animated video clips, audio sessions including interactive exercises and mindfulness sessions. Finally, indications of *validation* studies were sought on the app description and website.

The *pharmacotherapy* subdimension was coded on whether apps provided information about existing pharmacotherapies. For instance, apps can provide tablet intake instructions or support.

The *abstinence evaluation* subdimension was coded by categorizing the various self-monitoring possibilities offered by the apps. Most of the apps provided monitoring features such as an *unsmoked cigarettes* counter, *unsmoked days* representing the number of days since the smoker quitted, the number of *cigarettes smoked* since the installation of the app, the *interval* of time between two smoked cigarettes or the report of *cravings and urges*.

4.2 Source Credibility as Routine Use Influencer

As a second dimension of our review, the source credibility of each app was coded. Apps could be developed and published by everyone, enabling developers of any kind to come with their batch of smoking cessation interventions. Metadata found in an app's description, screenshots and website allowed the identification of the emitting authority of the app. Competence and trustworthiness are the two consistently emerging dimensions of source credibility [24]. Trustworthiness is a function of the perceived character and integrity of the source and can therefore not be universally categorized. Competence refers to expertise of the source. Coding was simply categorized as follows:

- *Unspecified.* No information about the people involved in the development process of the app is found.
- *Peer.* A smoker or an ex-smoker developed or participated in the development of the app.
- *Specialists.* The creation of the app involved medical professionals, researchers or universities.
- *Governmental.* A governmental institution, such as the public health department, mandated or participated in the development of the app.

4.3 User Engaging Motivational Affordance

As a third dimension of our review, user engagement was evaluated. According to Suh et al., [23]: *rewards*, *competition*, *self-expression* and *altruism* provide motivational affordance, being meaningful antecedents of needs satisfaction, stimulating intrinsic motivation (enjoyment) and causing users to engage more deeply in target activities within a gamified app. User engagement was coded by noting the presence of the following motivational affordances in the apps:

- *Rewards.* Through using the app, points are obtained as a pay-off for completing pre-designed tasks, such as staying smoke-free. By obtaining points, users can also reach levels or milestones rewarded by virtual badges and trophies demonstrating their accomplishments. Associated design elements are: points, levels and badges/trophies.
- *Competition.* Users engage in competition with each other through components such as leaderboards, enabling them to compare points, levels or badges. Associated design elements are: points, levels, badges and leaderboards.
- *Self-expression.* Personal identities can be defined through dynamics, allowing users to, for instance, create an avatar, upload a personal profile photo or communicating with emoticons expressing their emotions. Associated design elements are: points, levels, badges, leaderboards, avatars and emoticons.
- *Altruism.* Points and virtual goods can be exchanged between the users. For instance, a user can make a present by offering a virtual gift to another user. Associated design elements are: points and virtual gifts.

5 Results

The content of 99 apps was reviewed and coded, following the three previously presented dimensions: *evidence-based* practices adherence and *validation* studies, *user engagement* and *source credibility*. Table 3 presents the results of the analysis, with the supported subdimension and scores. Scores allow us to compare evaluated apps on the evidence-based, user engagement and source credibility dimensions. Scores range goes from 0 to 2, 0 representing a lowest level of adherence, 2 corresponding to the highest level of adherence. The addition of evidence-based, user engagement and source credibility scores provides the total score. Detailed attribution of scores is further detailed in Table 2.

Figure 3 provides an overview of the cumulative scores. The maximum achievable total score is 6. The best score of our sample is 6 and was obtained by only two apps (2%) while the average total score was 2.17. The average score for evidence-based adherence is 1.01. The average score for user engagement is 0.74. The average score for source credibility is 0.42. Of the reviewed apps, 10.1% do not support any evidence-based practice or any motivational affordance stimulating user engagement. Of the sample, 24.2% support some form of evidence-based practices without implementing any motivational affordances to increase user engagement. Finally, 72.7% of the reviewed apps do not provide

Table 2: Attribution of the dimensions' scores.

Score	***Evidence-Based***	***User Engagement***	***Source Credibility***
0	no use of any evidence-based practices	no use of motivational affordance	unknown emitting authority
1	use of at least one evidence-based practice	use of at least one motivational affordance design element	peer (e.g. ex-smoker) emitting authority
2	use of at least one evidence-based practice AND the app is backed up by scientific validation	use of two or more motivational affordances	specialists or governmental emitting authority

enough information to clearly identify the emitting authority and therefore the source credibility. Note that only 11% of the apps indicated that their efficacy was validated through a scientific study.

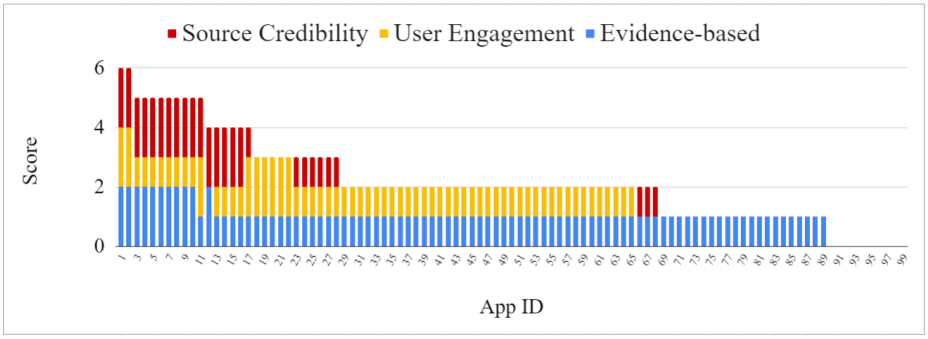

Fig. 3: Overview of the reviewed apps' scores.

Table 3: Overview of the reviewed apps sorted by score.

id	App name (Editor)	OS		Evidence-based									User Engagem			Source Cred.		Scores			
					Behav. Supp.				Abstinence Evaluation												
		Android	iOS	Validation	Brief Advice	Self-help	Peer-support	Program	Pharmacotherapy	Unsmoked cig.	Unsmoked days	Smoked cigarettes	Cigarettes Interval	Urges/Cravings	Rewards	Competition	Self-expression	Altruism	Peer	Specialists	Governmental	Evidence-based	User Engagement	Source Credibility	**Total**
1	Stop-tobacco (Université de Genève)	✓		✓	✓	✓	✓				✓				✓		✓			✓		2	2	2	6
2	Quit Genius - Best way to quit smoking for good (Digital Therapeutics)	✓	✓	✓		✓	✓	✓			✓				✓		✓			✓		2	2	2	6
3	Stoptober (Public Health England)	✓	✓	✓	✓	✓	✓	✓		✓	✓				✓				✓		✓	2	1	2	5
4	Craving To Quit! (Claritas MindSciences/Goblue International LLC)	✓	✓	✓	✓		✓	✓				✓			✓					✓		2	1	2	5
5	Quit Smoking - Stop Tobacco Mobile Trainer (Iteration Mobile S.L)		✓	✓	✓			✓				✓			✓					✓		2	1	2	5
6	Quit smoking - Smokerstop (Dr. med. Titus Brinker)	✓		✓	✓	✓				✓					✓					✓		2	1	2	5
7	Smoke Free - Stop Smoking Now (David Crane)		✓	✓	✓	✓					✓				✓					✓		2	1	2	5
8	2MorrowQuit (was SmartQuit) (2Morrow, Inc.)	✓	✓	✓				✓						✓	✓					✓		2	1	2	5
9	Smoke Free, quit smoking now and stop for good (The Quit Smoking Specialists)	✓		✓		✓	✓				✓				✓					✓		2	1	2	5
10	Stay Quit Coach (US Department of Veterans Affairs (VA))	✓	✓	✓		✓					✓				✓					✓		2	1	2	5
11	Quit Now: My QuitBuddy (ANPHA)	✓			✓	✓	✓					✓			✓		✓		✓		✓	1	2	2	5
12	Stop Tobacco Mobile Trainer. Quit Smoking App Free (Iteration Mobile & Vialsoft Apps)	✓		✓	✓	✓		✓				✓								✓		2	0	2	4
13	Smokefree (Public Health England)	✓	✓		✓			✓		✓				✓	✓						✓	1	1	2	4
14	Tabac info service, l'appli (l'Assurance Maladie)	✓	✓		✓	✓	✓								✓				✓		✓	1	1	2	4
15	Ex Smoker (Sopharma AD)	✓			✓	✓			✓	✓					✓					✓		1	1	2	4
16	Sacabo (Amarutek S.L.)	✓			✓				✓	✓					✓					✓		1	1	2	4
17	QuitNow! (Fewlaps, S.C)	✓	✓		✓	✓	✓			✓	✓				✓		✓		✓			1	2	1	4
18	Quit It - stop smoking today (digitalsirup)		✓			✓	✓			✓					✓	✓						1	2	0	3
19	Quit It Lite (digitalsirup)		✓			✓	✓			✓					✓	✓						1	2	0	3
20	Quitbit - Quit Smoking Cigarettes And Gently Stop (Quitbit, Inc)		✓			✓	✓					✓			✓		✓					1	2	0	3
21	Stop Smoking - EasyQuit free (Mario Hanna)	✓				✓				✓					✓		✓					1	2	0	3
22	Stop tabac - Quit smoking and cigarette cessation (Cedric Martin)		✓							✓					✓		✓					1	2	0	3
23	Quit Smoking Now: Quit Buddy! (HQmedia)	✓			✓	✓	✓	✓			✓				✓				✓			1	1	1	3
24	My Quit Smoking Coach (Andreas Jopp)	✓			✓	✓		✓		✓					✓				✓			1	1	1	3
25	Quit Smoking Pro (EpicLapps)	✓				✓	✓			✓					✓				✓			1	1	1	3
26	Quit Smoking: Cessation Nation (Ron Horner)	✓				✓	✓			✓	✓				✓				✓			1	1	1	3
27	Stop Smoking – quit smoking, be smoke free (The Quit Smoking Professionals)	✓				✓	✓			✓					✓				✓			1	1	1	3
28	LIVESTRONG MyQuit Coach (LIVESTRONG.COM)		✓				✓					✓			✓				✓			1	1	1	3
29	SmokeFree – quit smoking slowly (MotiveBite)	✓			✓	✓		✓		✓		✓	✓		✓							1	1	0	2
30	Quit Pro (Etago)		✓		✓	✓	✓			✓	✓				✓							1	1	0	2
31	quitSTART - Quit Smoking (ICF International)	✓	✓		✓	✓	✓				✓			✓	✓							1	1	0	2
32	101 days to quit smoking for good Free (GreenTomatoMedia)		✓		✓	✓					✓				✓							1	1	0	2
33	Quit Smoking - Quit now (Dhurandhar apps)	✓			✓	✓				✓					✓							1	1	0	2
34	Quit-Smoking Coach (Brainlag Studios)	✓			✓	✓				✓					✓							1	1	0	2
35	Quit-Smoking Coach Free (Brainlag Studios)	✓			✓	✓				✓					✓							1	1	0	2
36	QuitGuide - Quit Smoking (ICF International)	✓	✓		✓	✓								✓	✓							1	1	0	2
37	Smoke – quit (NikNormSoft)	✓			✓	✓				✓					✓							1	1	0	2
38	Quit Smoking Now: Stop Forever (TreePie)		✓		✓					✓					✓							1	1	0	2
39	Stop Smoking 3D (World Cloud Ventures)		✓			✓		✓			✓				✓							1	1	0	2
40	Drop It! Quit Smoking (Nikola Mladenovic)	✓				✓	✓			✓					✓							1	1	0	2
41	Kwit – quit smoking for good - smoking cessation (Kwit SAS)	✓	✓			✓	✓			✓	✓				✓							1	1	0	2
42	Smoke FREE Finally Non Smoking (sg-pages - Marcus Steller)	✓				✓	✓			✓					✓							1	1	0	2
43	Smoke Revoke - Gradually Quit Smoking (Alek Branch)		✓					✓				✓			✓							1	1	0	2
44	Cigarette Analytics (Alvakos)	✓				✓						✓			✓							1	1	0	2
45	Get Rich or Die Smoking (Tobias Gruber)	✓				✓				✓					✓							1	1	0	2
46	I Give Up Smoking (Stand Dev)	✓				✓				✓					✓							1	1	0	2
47	myQuitTime (Arete World Enterprises)		✓			✓				✓	✓				✓							1	1	0	2
48	myQuitTime Free (Arete World Enterprises)		✓			✓				✓	✓				✓							1	1	0	2
49	Quit Smoking - Goodbye Tobacco (Your Health)	✓				✓				✓	✓				✓							1	1	0	2
50	Quit Smoking - My Last Cigarette (Mastersoft)		✓			✓				✓					✓							1	1	0	2
51	Quit Smoking !!! (Dennis Ebbinghaus)		✓			✓				✓	✓				✓							1	1	0	2

Table 3: Overview of the reviewed apps sorted by score.

id	App name (Editor)	OS			Evidence-based										User Engagem				Source Cred.			Scores			
						Behav. Supp.				Abstinence Evaluation															
		Android	iOS	Validation	Brief Advice	Self-help	Peer-support	Program	Pharmacotherapy	Unsmoked cig.	Unsmoked days	Smoked cigarettes	Cigarettes Interval	Urges/Cravings	Rewards	Competition	Self-expression	Altruism	Peer	Specialists	Governmental	Evidence-based	User Engagement	Source Credibility	**Total**
52	Quit Smoking (Luis Salcedo)	✓				✓					✓				✓							1	1	0	2
53	Quit Smoking (Morisson Software)	✓				✓					✓				✓							1	1	0	2
54	Quit Tracker: Stop Smoking (despDev)	✓				✓				✓					✓							1	1	0	2
55	Qwit (Quit Smoking) (Team Geny)	✓				✓				✓					✓							1	1	0	2
56	Smoke FREE - Non Smoking (sg-pages)		✓			✓				✓	✓				✓							1	1	0	2
57	Stop & Quit Smoking – Smoke & vaping Cessation Now (Ibrahim Khalil)		✓			✓						✓			✓							1	1	0	2
58	Stop smoking helper (Roxoft)	✓				✓				✓					✓							1	1	0	2
59	Time To Quit Smoke (VantusMantus)	✓				✓				✓	✓				✓							1	1	0	2
60	Non Smoking Timer (LinQ)	✓									✓				✓							1	1	0	2
61	Quit Smoking - Butt Out (Ellisapps Inc.)		✓								✓	✓	✓		✓							1	1	0	2
62	Quit Smoking - Butt Out Pro (Ellisapps Inc.)		✓								✓	✓	✓		✓							1	1	0	2
63	Smoking reduction free (hashisoft)	✓										✓			✓							1	1	0	2
64	Smoking reduction Trial (hashisoft)	✓										✓			✓							1	1	0	2
65	Tabex – quit smoking (Sopharma Ukraine Limited Liability Company)	✓							✓						✓							1	1	0	2
66	Stop Smoking In 2 Hours (Juice Master)	✓	✓		✓			✓											✓			1	0	1	2
67	Quit Smoking Audio Help Tips Stop Now and Forever (Pitashi! Mobile Imagination.)		✓		✓		✓												✓			1	0	1	2
68	Stop Smoking Personal Stories of Success Quit Now (Pitashi! Mobile Imagination.)		✓		✓		✓												✓			1	0	1	2
69	Quit Smoking with Willpower (Pocket Pixels)		✓		✓	✓		✓					✓									1	0	0	1
70	Smoktivation : Ma motivation pour arrêter de fumer (JCD Software)		✓		✓	✓				✓	✓											1	0	0	1
71	Can I Smoke? (Steven Dakh)		✓			✓		✓					✓									1	0	0	1
72	Ecig-Coach (E-CIG GROUP)		✓					✓				✓										1	0	0	1
73	No smoking (antonfil84)	✓				✓	✓			✓	✓											1	0	0	1
74	Quit Smoking Hypnosis (Mindifi)	✓			✓			✓														1	0	0	1
75	Quit Smoking NOW - Max Kirsten (Life Change Media Ltd)		✓					✓		✓												1	0	0	1
76	iQuit - Stop Smoking Counter (Vidal de Wit)		✓			✓				✓	✓											1	0	0	1
77	Nextlater (App2Bizz)		✓			✓						✓										1	0	0	1
78	NoSmokingLife (bamboo)		✓			✓				✓												1	0	0	1
79	Quit Smoking (Azati)	✓				✓				✓		✓										1	0	0	1
80	Quit Smoking (HC)	✓				✓				✓	✓											1	0	0	1
81	Smokenote - Quit Smoking (NXCARE)	✓				✓						✓										1	0	0	1
82	Smoking Log - Stop Smoking (Cory Charlton)	✓										✓										1	0	0	1
83	Quit Smoking with Andrew Johnson (Michael Schneider)		✓			✓		✓														1	0	0	1
84	iCan Stop Smoking: learn self hypnosis and quit smoking (iCan Hypnosis)		✓					✓														1	0	0	1
85	Quit and Stop Smoking Hypnosis (Mindifi)		✓					✓														1	0	0	1
86	Quit Smoking Hypnosis Program (Mindifi)		✓					✓														1	0	0	1
87	Quit Smoking in 28 Days Audio Program (Pitashi! Mobile Imagination.)		✓					✓														1	0	0	1
88	Smoking Cessation Hypnosis (Hyptalk)		✓					✓														1	0	0	1
89	Stop Smoking! (On Beat Limited)		✓					✓														1	0	0	1
90	Cigarette Smoke Simulator Free (Gravy Baby Media)	✓																				0	0	0	0
91	Help You to Quit 100% (Nightingale WebApp)																					0	0	0	0
92	Roll and Smoke 3D FREE (Sakis25)	✓																				0	0	0	0
93	Simulator Cigarette Vape Joke (StarApps7)	✓																				0	0	0	0
94	Smoke a virtual cigarette (MaxZieli)	✓																				0	0	0	0
95	Smoke Cigarette Simulator (Yami Apps)	✓																				0	0	0	0
96	Smokerface (Dr. med. Titus Brinker)	✓																				0	0	0	0
97	Smoking virtual cigarettes (ScreenPranks)	✓																				0	0	0	0
98	Virtual cigarette (SmileTools)	✓																				0	0	0	0
99	Virtual Hookah/Shisha (Iris Studios and Services)	✓																				0	0	0	0
		61.6%	49.5%	11%	31.3%	61.6%	24.2%	25.3%	3.0%	43.4%	29.3%	19.2%	3.0%	6.1%	64.6%	2.0%	7.1%	0.0%	13.1%	12.1%	4.0%				
																					Average	1.01	0.74	0.42	2.17

6 Discussion

This research has shown that even though the subject is well-known, and smoking cessation apps are plentiful, research that provides information for system designers, users and medical professionals is not yet mature. One main issue is the lack of evaluation of smoking cessation apps. Of the 99 applications reviewed, only 11 (11%) were validated by scientific research, seven other apps (7.1%) claimed to be scientifically based, but no proof of this claim was found on the developer website. The lack of large empirical studies on effectiveness of smoking cessation apps provides an open avenue for future research. Furthermore, at this stage, most of the research papers referenced by the reviewed apps deal with the effectiveness of cognitive and behavioral theories [13, 26], but none deal with the app itself.

Current popular smoking cessation apps still have much room for improvement. Adherence to evidence-based guidelines and best practices continues to be low, as mentioned by previous research. It is often difficult to evaluate the source credibility, as most of the time the source is unknown or no guarantee of legitimacy is available. Regarding user engagement, the great majority of apps automatically reward smokers without requiring their intervention or being based on their actual behavior. In terms of motivational affordances, providing rewards is the most used mechanism. Although rewards are recognized as motivational affordances that encourage user engagement, they only weakly contribute to it when they are not coupled with other mechanisms (such as competition or self-expression) [23]. To maximize user engagement, future apps should consider such combinations.

The findings of this study should be interpreted in the context of certain limitations, the main limitation being that the apps were reviewed on the sole basis of the information provided by their developer (description, screenshots and website), which could be incomplete, erroneous or outdated. For a more comprehensive assessment, each app should be installed and used just as a smoker would.

While actual apps are potentially useful, they vastly underutilize the potential of mobile technologies. Mobile technology provides an unprecedented environment for reaching and interacting with smokers. Arguably the greatest strength of mobile technology is its ability to infer user activity, potentially providing a better idea of the smoker's actual behavior and in turn delivering personalized content in an appropriate context, in terms of space and time. Such technology also enables ubiquitous connectivity, enabling communication with peers and experts. Currently, popular apps only poorly implement such possibilities; for instance, only 2% permit smokers to engage in competition with peers and only one app (Quit Now: My QuitBuddy, ANPHA) provides access to experts through a quitline.

Future research should further exploit the opportunity of the device being in the smoker's pocket anytime and anywhere, thus providing an inconspicuous, accurate and efficient monitoring of smoking activity. Of the reviewed apps, only one (Quitbit, Quitbit Inc) uses a connected device (lighter) to monitor smoked

cigarettes. There is a lack of research into the evaluation of such tracking devices and their efficiency. These devices would definitely introduce an important feedback loop for the smoker's actual behavior with potentially high effectiveness [19, 6]. In addition, the sensors (e.g. GPS) already built into most smartphones make it possible for apps to provide sophisticated just-in-time and in-the-moment intervention for smoking cessation. Evaluation of previous smoking activity monitoring and digital support tailorization should be further investigated. A major challenge with such features is the privacy concern that they raise. It is therefore crucial to understand how to best find trade-offs to enable privacy-by-design while enabling personalization through data analytics.

Future work could also investigate social media interactions, which have been found to be poorly implemented. Designing interactions with peers (behavioral support functionalities) would not only reinforce the evidence-based practices, but would also facilitate the design, evaluation and understanding of what additional motivational affordances (competition, self-expression, altruism) are most effective besides rewards.

Finally, a majority of reviewed apps were emitted by an unspecified authority, leading to concerns of source credibility. Emitting sources of mHealth apps could be certified to help smokers in their choice. As interest in using apps for smoking cessation grows, it may become more difficult for consumers to find an app that is likely to be helpful. Further research should investigate how the emitting source could be legitimated and how sensitive content such as pharmacotherapy could be integrated.

7 Conclusion

This study provides an updated review of the most popular smoking cessation apps and suggests directions for further research to improve the efficacy of future digital support for smoking cessation. As interest in using apps for smoking cessation grows, it may be difficult for consumers to find an app that is likely to be helpful. Helping individuals quit smoking is a challenging task that requires an interdisciplinary approach. The volume of available apps makes the process of selecting a smoking cessation app difficult. The information systems community can provide support for this challenge by investigating how to best design digital support systems to help smokers quit. Even though there are a significant number of apps to help smokers quit, most of them are not aligned with evidence-based guidelines, nor are they encouraging user-engagement and source credibility, and there is also a lack of research for evaluating their effectiveness.

References

1. Abroms, L.C., Lee Westmaas, J., Bontemps-Jones, J., Ramani, R., Mellerson, J.: A content analysis of popular smartphone apps for smoking cessation. American Journal of Preventive Medicine **45**(6), 732–736 (2013)

2. Abroms, L.C., Padmanabhan, N., Thaweethai, L., Phillips, T.: iPhone apps for smoking cessation: A content analysis. American Journal of Preventive Medicine **40**(3), 279–285 (2011)
3. Bennett, M.E., Toffey, K., Dickerson, F., Himelhoch, S., Katsafanas, E., Savage, C.L.: A Review of Android Apps for Smoking Cessation (2014)
4. Bricker, J.B., Mull, K.E., Kientz, J.A., Vilardaga, R., Mercer, L.D., Akioka, K.J., Heffner, J.L.: Randomized, controlled pilot trial of a smartphone app for smoking cessation using acceptance and commitment therapy. Drug and Alcohol Dependence **143**(1), 87–94 (2014)
5. Cheng, F., Xu, J., Su, C., Fu, X., Bricker, J.: Content Analysis of Smartphone Apps for Smoking Cessation in China: Empirical Study. JMIR mHealth and uHealth **5**(7), e93 (2017)
6. Dijkstra, A., De Vries, H., Roijackers, J.: Long-term effectiveness of computer-generated tailored feedback in smoking cessation. Health Education Research **13**(2), 207–214 (1998)
7. El Ali, A., Matviienko, A., Feld, Y., Heuten, W., Boll, S.: VapeTracker: Tracking Vapor Consumption to Help E-cigarette Users Quit. Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (2016)
8. Hartmann-Boyce, J., Stead, L.F., Cahill, K., Lancaster, T.: Efficacy of interventions to combat tobacco addiction: Cochrane update of 2013 reviews. Addiction **109**(9), 1414–1425 (2014)
9. Health, A.U.S.P., Report, S.: A Clinical Practice Guideline for Treating Tobacco Use and Dependence: 2008 Update. A U.S. Public Health Service Report. American Journal of Preventive Medicine **35**(2), 158–176 (2008)
10. Hoeppner, B.B., Hoeppner, S.S., Seaboyer, L., Schick, M.R., Wu, G.W.Y., Bergman, B.G., Kelly, J.F.: How Smart are Smartphone Apps for Smoking Cessation? A Content Analysis. Nicotine & Tobacco Research **18**(5), 1025–1031 (5 2015)
11. Huang, S.c., Jin, L., Zhang, Y.: Step by step: Sub-goals as a source of motivation. Organizational Behavior and Human Decision Processes **141**, 1–15 (2017)
12. Information Consumer Health Corporation: Motivating Patients to Use Smartphone Health Apps. Tech. rep. (2011)
13. Lin, Y., Tudor-Sfetea, C., Siddiqui, S., Sherwani, Y., Ahmed, M., Eisingerich, A.B.: Effective behavioral changes through a digital mHealth app: Exploring the impact of hedonic well-being, psychological empowerment and inspiration. Journal of Medical Internet Research **20**(6) (2018)
14. Meng, F., Guo, X., Peng, Z., Zhang, X., Vogel, D.: The routine use of mobile health services in the presence of health consciousness. Electronic Commerce Research and Applications **35**(April), 100847 (2019)
15. Paay, J., Kjeldskov, J., Brinthaparan, U., Lichon, L., Rasmussen, S., Srikandaraja, N., Smith, W., Wadley, G., Ploderer, B.: Quitty: Using Technology to Persuade Smokers to Quit. Proceedings of the 8th Nordic Conference on Human-Computer Interaction Fun, Fast, Foundational – NordiCHI '14 (2014)
16. Pernencar, C., Sousa, P., Frontini, R., Martinho, R., Runte, D., Mendes, D., Carvalho, M.: Planning a health promotion program: Mobile app gamification as a tool to engage adolescents. Procedia Computer Science **138**, 113–118 (2018)
17. Sama, P.R., Eapen, Z.J., Weinfurt, K.P., Shah, B.R., Schulman, K.A.: An evaluation of mobile health application tools. JMIR mHealth and uHealth **2**(2), e19 (5 2014)
18. Sardi, L., Idri, A., Fernández-Alemán, J.L.: A systematic review of gamification in e-Health. Journal of Biomedical Informatics **71**, 31–48 (2017)

19. Smith, S., Roberts, N., Kerr, S., Smith, S.: Behavioral Interventions Associated with Smoking Cessation in the Treatment of Tobacco Use. Health Services Insights p. 79 (2013)
20. Stead, L., Carroll, A., Lancaster, T.: Group behaviour therapy programmes for smoking cessation (Review). Cochrane Database of Systematic Reviews Group (3) (2017)
21. Strauss, A., Corbin, J.: Basics of qualitative research. Sage publications (1990)
22. Strauss, A.L.: Qualitative analysis for social scientists. Cambridge university press (1987)
23. Suh, A., Wagner, C., Liu, L.: Enhancing User Engagement through Gamification. Journal of Computer Information Systems **58**(3), 204–213 (2018)
24. Sussman, S.W., Siegal, W.S.: Informational influence in organizations: An integrated approach to knowledge adoption. Information systems research **14**(1), 47–65 (2003)
25. Thornton, L., Quinn, C., Birrell, L., Guillaumier, A., Shaw, B., Forbes, E., Deady, M., Kay-Lambkin, F.: Free smoking cessation mobile apps available in Australia: a quality review and content analysis. Australian and New Zealand Journal of Public Health **41**(6), 625–630 (2017)
26. Tudor-Sfetea, C., Rabee, R., Najim, M., Amin, N., Chadha, M., Jain, M., Karia, K., Kothari, V., Patel, T., Suseeharan, M., Ahmed, M., Sherwani, Y., Siddiqui, S., Lin, Y., Eisingerich, A.B.: Evaluation of two mobile health apps in the context of smoking cessation: Qualitative study of cognitive behavioral therapy (CBT) versus Non-CBT-based digital solutions. Journal of Medical Internet Research **20**(4) (2018)
27. Verbiest, M., Brakema, E., Van Der Kleij, R., Sheals, K., Allistone, G., Williams, S., McEwen, A., Chavannes, N.: National guidelines for smoking cessation in primary care: A literature review and evidence analysis. npj Primary Care Respiratory Medicine **27**(1), 0–1 (2017)
28. West, R., Raw, M., McNeill, A., Stead, L., Aveyard, P., Bitton, J., Stapleton, J., McRobbie, H., Pokhrel, S., Lester-George, A., Borland, R.: Health-care interventions to promote and assist tobacco cessation: A review of efficacy, effectiveness and affordability for use in national guideline development. Addiction **110**(9), 1388–1403 (2015)
29. WHO: Global action plan for the prevention and control of noncommunicable diseases 2013–2020. World Health Organization p. 102 (2013)
30. WHO: Tobacco (2019), http://www.who.int/news-room/fact-sheets/detail/tobacco