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A systematic review

Citation for published version:

Zhang, M, Wolters, M, O'connor, S, Wang, Y & Doi, L 2023, 'Smokers' user experience of smoking cessation apps: A systematic review', *International journal of medical informatics*, vol. 175, 105069. <https://doi.org/10.1016/j.ijmedinf.2023.105069>

Digital Object Identifier (DOI):

[10.1016/j.ijmedinf.2023.105069](https://doi.org/10.1016/j.ijmedinf.2023.105069)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Publisher's PDF, also known as Version of record

Published In:

International journal of medical informatics

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Review article

Smokers' user experience of smoking cessation apps: A systematic review

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ARTICLE INFO

Keywords:

Smoking cessation
mHealth
Mobile app
User experience
Smoker

ABSTRACT

Objectives: To explore how smokers view common functions and characteristics of smoking cessation apps.**Design:** Systematic review.**Search sources:** CINAHL PLUS, MEDLINE, PsycINFO, EMBASE, IEEE Xplore, ACM Digital Library, and Google Scholar.**Review methods:** Seven digital databases were searched separately using relevant search terms. Search results were uploaded to Covidence. Inclusion and exclusion criteria were identified with the expert team in advance. Titles, abstracts, and full texts were screened by two reviewers independently. Any disagreements were discussed in research meetings. Pertinent data were extracted and analysed using qualitative content analysis. Findings were presented in a narrative approach.**Results:** 28 studies were included in this review. The overarching themes were app functionality and app characteristics. Under app "functionality", six subthemes emerged: 1) education; 2) tracking; 3) social support; 4) compensation; 5) distraction, and 6) reminding. Under "app characteristics", five subthemes emerged: 1) simplification, 2) personalisation, 3) diverse content forms, 4) interactivity, and 5) privacy and security.**Conclusion:** Understanding user needs and expectations is crucial for developing a programme theory for smoking cessation app interventions. Relevant needs identified in this review should be linked to broader theories of smoking cessation and app-based intervention.

1. Introduction

Tobacco use is addictive, and it is a major risk factor for respiratory diseases, heart conditions and over twenty types or subtypes of cancer [54]. In addition, tobacco use causes more than eight million deaths globally each year due to the mixture of chemicals that damage lung tissue when inhaled [54].

With the growth of mHealth, in particular during the Covid-19 pandemic, mobile apps have been increasingly adopted as an aid to smoking cessation [12,1]. Smoking cessation apps do not rely on chemical agents that might interact with other medications or cause physical side effects. Apps can be accessed anytime and anywhere, as long as the user has their phone with them, and can potentially be personalised based on smokers' preferences and needs [44,31]. Apps can be used for short interactions with counsellors, if needed [34], provide just-in-time support when smokers need it [29,40], or be integrated with face-to-face counselling [3].

Several literature reviews have examined aspects of mobile smoking cessation interventions [51,52,14,17,46,3].

Ghorai et al. [14] reviewed mHealth intervention designs for smoking cessation. All 15 studies were randomised controlled trials conducted in developed countries. Nine studies used self-reported smoking cessation measures and six used biochemical validations such as determination of salivary cotinine level. Most mHealth services in this review only used short message systems (SMS) and multimedia-based messaging to send reminders, and provided additional functionality such as motivational messages, social contacts, and peer support. While these are simpler interventions than smartphone apps, apps often cover similar functionality. Ghorai et al. noted that none of those studies reported on user acceptance tests.

A Cochrane review which included any smoking cessation interventions aimed at mobile phone users [51,52] also found evidence of potentially positive effects, although there was significant unexplained heterogeneity. Again, the interventions were predominantly text

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messaging-based, and all included studies were conducted in high-income countries with good tobacco control policies.

In a recent systematic review of the effectiveness of mHealth for smoking cessation, Barroso-Hurtado et al. [3] identified 24 studies, only 6 of which were of high methodological quality. Nine apps were designed to be used by smokers themselves, while fifteen supported face to face interventions. Overall, apps were at least as successful as control interventions, but outcomes varied.

One reason for this might be the varying quality of smoking cessation apps. Thornton et al. [46] investigated the quality of 112 apps using two criteria: adherence to the Australian smoking cessation treatment guidelines [58] and overall quality as rated using the Mobile App Rating Scale [43], which consists of 23 items in five categories: aesthetics, engagement, functionality, information, and subjective quality. Among the 112 apps, only six were high-quality and partly adhered to the guidelines and these were more likely to help people stop smoking.

Haskins et al. [17] examined how many of the top commercially available apps for smoking cessation were supported by the published scientific literature and how many scientific apps were available to smokers. They reported customers found it difficult to access smoking cessation apps which were scientifically supported, and among the six high-quality apps identified in the review, only three were accessible to customers.

None of the existing reviews focus on the user experience of smoking apps, even though the uptake of and adherence to app-based interventions is substantially affected by the user experience. Existing reviews focus on quantitative data, not on qualitative views and perspectives while qualitative views and perspectives are essential in providing a rich and nuanced understanding of users' motivations, experiences, beliefs, opinions etc. in using smoking cessation apps. For example, users may expect different features, which may not be captured by quantitative data on usage patterns. Furthermore, qualitative data provide valuable insights into how users perceive and engage with apps and can inform the design and development of better software interfaces and more useful functional features. Finally, qualitative data highlights the social and cultural contexts in which smoking cessation apps are used, such as commonly held views on smoking and its addictiveness.

Following ISO 9241-210:2019, we define user experience as "a person's perceptions and responses resulting from the use and/or anticipated use of a product, system, or service" [20]. The aim of this review is to synthesise what is known about qualitative aspects of smokers' user experience of smoking cessation apps, leading to the research question: *What are relevant perspectives, views, beliefs, attitudes, opinions, or experiences that smokers have regarding smoking cessation apps?* For the purpose of this review, we focused on smokers' experience of smoking cessation apps themselves, not on their attitudes to and reasons for smoking and smoking cessation. While underlying attitudes or motivations for smoking are highly relevant for smoking cessation, this is beyond the scope of this study, which focuses on mobile tools for quitting smoking.

Together with relevant behaviour change theories, findings can be used for the development of programme theories of smoking cessation apps and inform the design of new, evidence-based apps.

2. Methods

2.1. Search strategy

CINAHL PLUS, MEDLINE, PsycINFO, EMBASE, IEEE Xplore, and the ACM digital library were searched for relevant studies using the search terms summarised in Table 1. The search strategy was discussed and agreed amongst the research team (MZ, LD, MW, SO). There was no restriction of publication year or language. Study subjects were restricted to humans in EMBASE and MEDLINE. Since content in IEEE Xplore and the ACM Digital is highly likely to be mHealth or eHealth related, queries were simplified to focus on smoking cessation apps. We

Table 1

Search terms used within electronic databases.

Database	Search terms
CINAHL PLUS	<ol style="list-style-type: none"> (MH "smoking cessation") OR ("smoking cessation" OR "quit* smoking" OR "stop* smoking" OR "cease* smoking" OR "tobacco use cessation" OR "quit* tobacco use" OR "stop* tobacco use" OR "antismok*" OR "cigarette reduction" OR "smoking reduction" OR "reduced tobacco consumption").mp. (MH "telehealth") OR ("mobile health" OR "m health" OR mhealth OR "mobile app* OR smartphone* OR smart phone* OR mobile app* OR cell phone* OR handheld* OR "mobile device*" OR "mobile device*" OR ipad OR iphone OR android OR iOS OR blackberry OR "telemedicine").mp. (perspect* OR belief* OR attitude* OR view* OR opinion* OR experien* OR behavio* OR expect* OR knowledge).mp.
MEDLINE	<ol style="list-style-type: none"> ("smoking cessation" OR "quit* smoking" OR "stop* smoking" OR "cease* smoking" OR "tobacco use cessation" OR "quit* tobacco use" OR "stop* tobacco use" OR "antismok*" OR "cigarette reduction" OR "smoking reduction" OR "reduced tobacco consumption").mp. OR exp smoking cessation OR exp smoking reduction OR exp tobacco use cessation ("mobile health" OR "m health" OR mhealth OR "mobile app* OR smartphone* OR smart phone* OR mobile app* OR cell phone* OR handheld* OR "mobile device*" OR ipad OR iphone OR android OR iOS OR blackberry OR "telemedicine").mp. OR exp mobile applications OR exp telemedicine OR exp smartphone OR exp software OR exp internet OR exp cell phone OR exp computers, handheld (perspect* OR belief* OR attitude* OR view* OR opinion* OR experien* OR behavio* OR expect* OR knowledge).mp.
PsycINFO	<ol style="list-style-type: none"> ("smoking cessation" OR "quit* smoking" OR "stop* smoking" OR "cease* smoking" OR "tobacco use cessation" OR "quit* tobacco use" OR "stop* tobacco use" OR "antismok*" OR "cigarette reduction" OR "smoking reduction" OR "reduced tobacco consumption").mp. OR exp smoking cessation OR exp nicotine withdrawal ("mobile health" OR "m health" OR mhealth OR "mobile app* OR smartphone* OR smart phone* OR mobile app* OR cell phone* OR handheld* OR "mobile device*" OR ipad OR iphone OR android OR iOS OR blackberry OR "telemedicine").mp. OR exp mobile applications OR exp telemedicine OR exp smartphones OR exp computer softwares OR exp internet OR exp mobile devices OR exp tablet computers OR exp mobile phones perspect* OR belief* OR attitude* OR view* OR opinion* OR experien* OR behavio* OR expect* OR knowledge
EMBASE	<ol style="list-style-type: none"> ("smoking cessation" OR "quit* smoking" OR "stop* smoking" OR "cease* smoking" OR "tobacco use cessation" OR "quit* tobacco use" OR "stop* tobacco use" OR "antismok*" OR "cigarette reduction" OR "smoking reduction" OR "reduced tobacco consumption").mp. OR exp smoking cessation OR exp smoking reduction OR exp smoking cessation program ("mobile health" OR "m health" OR mhealth OR "mobile app* OR smartphone* OR smart phone* OR mobile app* OR cell phone* OR handheld* OR "mobile device*" OR ipad OR iphone OR android OR iOS OR blackberry OR "telemedicine").mp. OR exp mobile application OR exp telemedicine OR exp mobile phone OR exp telehealth OR exp tele nursing OR exp mobile health application OR exp smartphone OR exp software OR exp internet perspect* OR belief* OR attitude* OR view* OR opinion* OR experien* OR behavio* OR expect* OR knowledge
ACM digital library	<ol style="list-style-type: none"> smok* OR vape* OR e-cigarettes stop* OR quit* OR cessation OR anti-vaping OR behavior*) AND (smok* OR vape* OR "e-cigarettes") AND (mHealth OR ehealth OR smart OR *health* OR app)
IEEE Xplore	

excluded specific user experience or usability related terms since this is rarely signposted in title, abstract, or keywords. The term "smokers' views on smoking cessation apps" was used in Google Scholar to identify additional papers (n = 2).

2.2. Inclusion and exclusion criteria

Inclusion and exclusion criteria using the Population, Intervention,

Table 2
Inclusion and Exclusion criteria.

PICO domain	Inclusion criteria	Exclusion criteria
Population	Adult smokers 18 years old and above	Adolescent smokers aged below 18 years old
Intervention	Any smoking cessation app	Interventions were not mobile apps, such as web-based programmes, text-messaging programmes, telephone counseling, quitlines, mini-programmes based on a social network, or mobile phones are used as an adjunct to other interventions, such as face-to-face programmes.
Comparison	N/A	N/A
Outcome	Perspectives, beliefs, attitudes, views, opinions, knowledge, experiences, behaviours or expectations of using apps in smoking cessation	Outcome was not smoking cessation or relapse prevention; paper did not provide any qualitative results

Comparison, Outcome (PICO) framework [39] are provided in Table 2.

2.3. Study selection

Study selection was conducted individually by two reviewers (MZ and YW). Covidence [7] was used to screen titles, abstracts and full texts. Two reviewers (MZ and YW) separately screened titles and abstracts and resolved any conflicts through discussion. During the independent full-text screening, both reviewers used Covidence to note reasons for exclusion. Conflicts regarding eligibility or exclusion reasons were resolved through discussion, with LD and MW providing advice. The study selection process is summarised in Fig. 1. There were 12,272 papers identified through database searching, leaving 4243 papers after removing duplicates. 54 papers were included in the full text review. 28 studies were excluded: 17/28 (61%) contains no qualitative components; 3/28 (11%) had no full-text online; 8/28 (29%) did not refer to smoking cessation apps. Hand search in Google Scholar resulted in two additional papers. Enhancing transparency in reporting the synthesis of qualitative research (ENTREQ) was followed to report this qualitative systematic review [47].

2.4. Data extraction and analysis

Data extraction was conducted by MZ using a custom Excel extraction form, which covered study characteristics and findings. The extraction was independently checked by LD and MW for consistency. The findings were summarised using keywords or short sentences taken from the qualitative analysis and loosely grouped into categories: Users wanted, for features that were desired, but not available, Users liked, for features that users were positive about, and Users disliked, for features that users were negative about. The findings were synthesised using inductive content analysis to identify themes across studies. The framing of the content analysis was developer-centric in that we focused on patterns related to properties of apps. During the synthesis process, we used this lens to repeatedly read through the included studies until no new patterns emerged and saturation was reached [22]. The resulting patterns were mapped onto main themes and subthemes. QSR NVivo was utilised to facilitate coding. Once the themes had been identified, quotes from the source papers were used to examine themes in more detail.

3. Results

3.1. Study characteristics

There were 28 studies included in this review. All included studies were conducted in high-income countries, with seven in the United Kingdom, six in the USA, four in Denmark and Australia, three in Canada, and one each in Finland, Spain, the Netherlands, and Romania. Although we did not set any publication year limitations, all included studies were conducted between 2014 and 2022.

Nearly all studies focused on a specific smoking cessation app in the study, except for Gowarty et al. [15], who explored the overall attitudes toward smoking cessation apps and preferences regarding app design, and Bendotti et al. [5], who examined app reviews in app stores. Among the included studies, 15/28 targeted general adult smokers, 5/28 targeted smokers with mental health conditions, 3/28 targeted young smokers; 2/28 targeted women smokers; 1/28 targeted at lower socio-economic status (SES) smokers, and 1/28 targeted smokers who are taking psychiatric medication. Since Bendotti et al. [5] explored app reviews, no targeted participants were identified in this study. In terms of apps, Crush the Crave were evaluated in three studies; QuitGuide and QuittyLink were evaluated in two studies; and all other apps were only evaluated in one study. The majority of the studies included in this

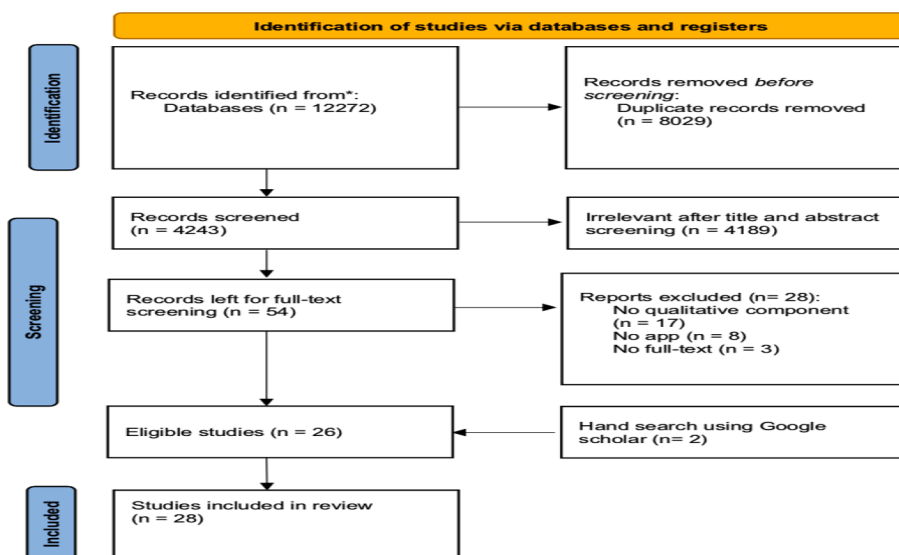


Fig. 1. PRISMA flowchart of the screening process.

review focused on research-based apps or apps developed specifically for research that employed evidence-based strategies validated through rigorous research and testing conducted by authors or reputable research institutions. However, there were three studies that investigated apps sourced from app stores [5,11,56], one examined a commercial app [33], and one study did not explore a specific app [15].

The details of included papers are shown in Table 3.

3.2. Qualitative findings

Qualitative analysis yielded two high level themes, app functions and app characteristics (Table 4). The App Functions theme had six sub-themes: 1) education (n = 14); 2) tracking (n = 21); 3) social support (n = 19); 4) compensation (n = 12); 5) distraction (n = 13), and 6) reminding (n = 14). Each theme is explored in more detail below. The App Characteristics theme had five sub-themes: 1) simplification (n = 18); 2) personalisation (n = 17); 3) diverse output forms (n = 7); 4) interactivity (n = 14); 5) privacy and security (n = 4). Relevant quotes to support each theme are listed in Table 5a and Table 5b.

3.2.1. App functions

3.2.1.1. Education. Education meant providing information to smokers, not only showing them what they could gain and lose through smoking cessation [48] but also teaching them to cope with negative emotions such as anxiety as well as urges and cravings to smoke [56,38,18,24].

Participants wanted apps to provide more information [15,28,33] going beyond what they already knew [33,11]. Users preferred to receive positive information [24,40,31,10,44] from experts [42,31] or other smokers in a similar situation [56]. Educational information should be tailored to individual needs [33], with content updated regularly to increase engagement with a smoking cessation app [56,33,11].

3.2.1.2. Tracking. Tracking was the most frequently mentioned app function. It allows users to document when, where, or how many cigarettes users smoked and provides feedback, usually through visualisations. Tracking can not only measure progress of quitting [31,11,2,18,16,5], but also make users more self-aware of their smoking patterns and psychological triggers to smoke [5,21,44,50,40,15,48,28]. Some apps even can show the location where users smoked using a map [40,30]. The challenge of tracking is that users sometimes struggled to report smoking in real time [30].

3.2.1.3. Social support. Having a social support function meant users could get encouragement and support from and share their quitting progress with their family, friends, other smokers, and physicians through stories or competition [31,4,35,48,42,5]. In a study with people with mental conditions, through the social support function, the app had the potential to decrease stigma, sense of loneliness [21]. Smith et al. [42] reported that participants preferred to use the app's sharing function to interact with other people who were trying to quit smoking and valued the anonymity of the social function on the app, rather than sharing information openly on social media such as Facebook. Bendotti et al. [5] found that users' sense of achievement and motivation could be boosted through sharing their progress with friends. Although social support functions were appreciated by most smokers, some users thought it unnecessary or were unwilling to share their smoking cessation attempts or progress on social platforms [56,16,11,45].

3.2.1.4. Compensation. Compensation functions in the smoking cessation apps focused on calculating money saved, cigarettes saved, abstinence (smoke-free) days, physical health rewards, or providing psychological rewards, including gamification, which seemed to help improve confidence and motivate some people to quit smoking

[49,33,2,10,4,45,44,24,18,15,16]. For example, virtual rewards, such as imagery or recordings of walking in fresh air and listening to birds singing, was appreciated by some users [2,24], while other participants wanted psychological rewards such as digital badges to increase the quitting motivation [15].

3.2.1.5. Distraction. Many smoking cessation apps helped users to occupy their minds with other things, such as games, videos, music, or social media [33,42,45,18,35,50,10,48,5] or suggested users perform physical exercise [24] or have something to eat or drink [4] to distract them from smoking or craving events. For instance, in Struik et al. [45], young smokers preferred games to YouTube videos, as games kept their hands busy to distract them from smoking. Similarly, participants in Wu et al. [56] wanted the app to add some distraction function such as breathing exercises or games.

3.2.1.6. Reminding. Reminders were used to prompt people to use the smoking cessation app, to inform them of their progress, or just to send motivational messages [31,33,34,49,30,48,40,45,35,24,15,16,18,5].

Although some found reminders or notifications annoying, especially at inconvenient times [31,49], most users found them useful motivational tools [31,34,49,45,48,18,16]. Notably, users seemed to prefer to receive reminders from a real person, not a machine, as this was more motivating to stop smoking [33,31,34]. A handful of studies reported that too frequent reminders may have counterproductive effects and could prompt people to smoke or lead to disengagement from the app due to lack of personalisation [5,40,33,35,24,15].

3.2.2. App characteristics

3.2.2.1. Simplification. Simplification meant the smoking cessation apps should be quick and easy to use [32,34,11,49,56,13,48,24,25,35,21,50,44,18,38,16,5,28]. If an app was not intuitive and easy to follow, users needed further training or guidance on how to use it [48,21,35]. Vilardaga et al. [50] found that people with serious mental health conditions felt stressed if the app was not simple to use.

3.2.2.2. Personalisation. Several studies noted that the design of smoking cessation apps should be tailored to the target population, as each person/group such as young smokers or those with mental health conditions may have specific smoking habits and quitting requirements.

For example, in Struik et al. [44], men did not want to share personal things in apps, while women were more inclined to draw on social support in the smoking cessation app. Participants wanted personalised reminders, counselling messages and tips [32,34,49,30,56,10,48,21,25,35,5], tailored quitting dates and plans [10], tailored educational information [45], personalised rewards [11], or tailored tracking modes [4]. Bendotti et al. [5] found that app users' personal accountability could be reinforced through the ability to personalise their quit plans.

3.2.2.3. Diverse content forms. Instead of using just text-based information on smoking cessation, various forms of content such as images, videos, audio were appreciated [30,2,56,48,13,18,38]. Some participants thought audio was more convenient since they could play the audio when doing other activities and felt more engaged with the audio narrations. In addition, users preferred to add background music to audio files so they can be more relaxed [2].

3.2.2.4. Interactivity. Interactivity was highlighted in several studies. In addition to functions such as social support and interactive distractions, discussed above, quizzes were another potential interactive component. Interactivity by users to avoid boredom and increase engagement with the app [31,33,49,50,42,56,48,10,45,44,35,18,15,5].

3.2.2.5. Privacy and security. Privacy and security when using a

Table 3
Details of included papers.

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
1	Armin et al. [2]/ USA	Aim: To gain users' opinions to refine app content. Setting: Not reported.	Design: Qualitative descriptive design. Data collection: Focus group, Questionnaire, User testing. Data analysis: An inductive approach to analysis.	Adult female smokers who are interested in quitting (N = 15).	See me Smoke Free Sources: Investigators used qualitative methods guided by a theoretical framework which considers the interrelationships between multiple psychosocial mediators of smoking cessation, and evidence-based guidelines to develop and refine the app.	YES	Users wanted the app: 1. Had lengthier audio files: bring attention to positive and allow more time to evoke the described images; 2. Adding background music; 3. Reinforced women's confidence in quitting; 4. Highlighted the rewards of quitting; 5. Adding imagery files; 6. Clarify the relationship between smoking cessation, good diet, and improved physical activity: Participants suggested we emphasize how the physical benefits of individual behaviour changes will affect other behaviours; 7. More clearly recognized the struggle involved in quitting; 8. Celebrate the accomplishment. Users liked the app: 1. "money-saved" counter would motivate them to continue a smoke-free lifestyle; 2. Seeing their cigarette cravings change from high to low on the tracking graph can make potential pleasure.
2	Baskerville et al. [4]/ Canada	Aim: To describe the process of developing Crush the Crave (CTC) and to evaluate the effectiveness of this app. Setting: Not reported.	Design: Five iterative cycles: listen, plan, do, act, and study using a STAR model. Data collection: Focus group. Data analysis: Thematic framework.	Adult smokers (N = 57), 31 males, 26 females.	Crush the Crave Sources: The design of this app was underpinned by the US Clinical Practice Guidelines for quitting smoking and principles of persuasive technology for behaviour change	YES	Users wanted the app to cover: 1. Positive reinforcement, such as encouragement and rewards; 2. Personalisation; 3. Social support: social networking, networking with other app users, quit buddies; 4. Quit support: distraction, immediate support, flexible quit approach; 5. Tracking the behaviour: identifying triggers and frequency; 6. Tracking quit benefits: money saved and health benefits. Users liked the app: 1. Enabling users to set goals, track progress and smoking habits; 2. Containing health information; 3. Sending reminders of their progress; 4. Enabling users to personalise their plans; 5. Providing app communities or message boards to enhance support; 6. Can interact with other social media apps.
3	Bendotti et al. [5]/ Australia	Aim: To explore the opinions and experiences of Android and Apple mCessation app users via qualitative analysis of unsolicited consumer reviews to (1) determine key design factors and features which positively and negatively influence user experience; (2) identify user needs, experiences, and expectations of apps, including suggested improvements; and (3) outline recommendation for designing effective mCessation apps. Setting: Not reported.	Design: Mixed methods approach by collecting (1) qualitative data via a targeted search strategy to identify user reviews; (2) quantitative data via MARS and user star ratings to determine mean objective and subjective ratings of app quality. Data collection: A web-crawler source code to identify mCessation apps and collect their associated reviews from the Google Play store (Android) and the App Store (Apple) Data analysis: Thematic analysis	N/A	Forty-eight versions of 42 apps met eligibility criteria. Sources: N/A	NO (Apps in Google Play and Apple Store)	Users wanted the app: 1. Personalisation; 2. Functionality; 3. Relationality; 4. Credibility

(continued on next page)

Table 3 (continued)

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
4	El-Hilly et al. [11] / UK	Aim: To investigate how the gamification of mHealth interventions leads to a change in health behaviours, especially smoking behaviour. Setting: Not reported.	Design: A qualitative longitudinal study. Data collection: Semi-structured interviews. Data analysis: 6-phase analytic framework.	Adult smokers (N = 16), 11 males, 5 females.	Puff away / Kwit 2 Sources: N/A	NO (Downloaded from App Stores)	Users wanted the app to be: 1. Easy to use; 2. Providing knowledge which they did not know before; 3. Personalised; 4. Adding an element of fun to the game; 5. Adding a social community which they could interact with like-minded individuals.
5	Edwards et al. [10] / UK	Aim: To present a series of steps undertaken during the development of Cigbreak, a gamified smoking cessation app. Setting: University.	Design: 7-stage design. Data collection: Focus group. Data analysis: Thematic analysis.	Adult smokers (N = 73), 34 males and 39 females.	Cigbreak Sources: A group of clinicians, researchers, and game developers, in collaboration with end users developed the app, which included gamification and theoretically validated Behaviour Change Techniques.	YES	Users wanted the app to cover: 1. Focused more on positive outcomes of quitting and emotions rather than negative; 2. Smokers felt that personalisation was an important function, including ability to set personal quit dates, plans, record relapses, and receive tailored text messages; 3. The idea of a personalized diary to incorporate these aspects was popular among the smokers as were links to local pharmacies/quit services.
6	Fulton et al. [13] / UK	Aim: To translate behaviour change technique concepts into digital content within the app. Setting: Not reported.	Design: Participatory design focusing on person-centred approaches. Data collection: “Think aloud” session. Data analysis: Top-down coding.	Adult smokers or ex-smokers (N = 4), 4 males.	StopApp Sources: “Co-creation” of the app based on evidence-based behaviour change component	YES	Users liked the app: 1. Provided testimonials; 2. Can send reminders to use the app; 3. Provided appointment time and date choices; 4. Sent motivation messages without excessive pressure. Users disliked the app: 1. Not presented in an appealing way, with a relatively poor structure and too much text; 2. Not intuitive, needing guidance to navigate the app.
7	Gowarty et al. [15] / USA	Aim: To explore attitudes toward smoking cessation apps and preferences regarding app design in young adult smokers with serious mental illness. Setting: A community mental health care.	Design: An exploratory qualitative study Data collection: Focus groups Data analysis: Thematic analysis	Adult smokers with serious mental illness (N = 22), 10 females.	N/A	N/A	Users wanted the app: 1. Receiving support from other people within the app; 2. Feedback about progress (such as cigarettes avoided, or money saved); 3. Rewards such as financial incentives or badges; 4. Providing distraction to avoid cigarettes; 5. To be informative; 6. Tracking their smoking behaviours.
8	Gowarty et al. [16] / USA	Aim: To determine the user experience, usability, and acceptability of QuitGuide and quitSTART—among young adult tobacco users with severe mental diseases. Setting: A community mental health	Design: Mixed method approach Data collection: Semi-structured interviews. Data analysis: Thematic analytical techniques.	Adult smokers receiving mental health treatment: Adult smokers (N = 17), 7 females, 10 males.	QuitGuide / quitSTART Sources: The National Cancer Institute provided the two apps based on behavioural change theories and clinical practice guidelines	YES	Users liked the app: 1. Easy to use; 2. Used a positive and supportive tone 3. Provided motivational quotes and feedback on money saved; 4. Could track the smoking behaviour; 5. The notification function reminded them to use the app.

(continued on next page)

Table 3 (continued)

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
		centre.					<p>Users disliked the app: 1. Navigation difficulty during the first visit; 2. A negative tone or repeated reminders of a lack of progress would evoke feelings of guilt and failure, which could undermine their quit attempts.</p> <p>Users wanted the app to cover: 1. Adding a tracking function that enabled them to track cutting down, which they felt was important to frame their progress positively; 2. Having more sections in the apps where they could enter free-text responses to prompts (such as their moods or their triggers for smoking) instead of choosing from a prepopulated menu; 3. Personalisation.</p>
9	Herbst et al. [18]/ USA	<p>Aim: To examine the acceptability, user experience, and perceptions of the app.</p> <p>Setting: Not reported.</p>	<p>Design: Qualitative evaluation design.</p> <p>Data collection: Semi-structured interviews.</p> <p>Data analysis: Thematic analysis.</p>	Smokers who were military veterans with posttraumatic stress disorder (PTSD) (N = 17), 17 males.	<p>Stay Quit Coach</p> <p>Sources: The National Centre for PTSD designed the app based on behavioural and pharmacotherapy treatment</p>	YES	<p>Users liked the app: 1. The psychoeducational information on PTSD; 2. The calculator function was described by some as a helpful and motivating way to visualize their progress; 3. The reminders of their personal reasons to quit, self-scheduled motivational messages delivered as push notifications and tools for coping with stress and negative emotions were helpful.</p> <p>Users disliked the app: 1. Issues with using the money-saved calculator while reducing cigarette use (eg, unable to use this function unless one has already quit smoking); 2. The timing of reminders and notifications, eg, inability to adequately customize timing of the notifications; 3. Users needed guidance to use the app; 4. The app did not have enough privacy.</p> <p>Users wanted the app to cover: 1. Increased level of engagement and interactivity with the user; 2. Personalisation; 3. Being able to share progress with others through texts or social media if desired; 4. More opportunities for social interaction and social support within the app; 5. Incorporating content such as news updates or</p>

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Table 3 (continued)

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
							current events news feed; 6. Ability to store data within “the cloud”; 7. Incorporating games or other functions for distraction; 8. Increased ability to track ones use of coping tools and cigarette use, as well as other tobacco products to monitor and detect patterns in craving onset; 9. Adding graphs in tracking function; 10. Reducing the typing burden.
10	Klein et al. [21]/ Australia	Aim: To explore the feasibility, acceptability, and utility of Kick.it to assist smokers with severe mental diseases to prevent smoking relapse and quit. Setting: Not reported.	Design: Co-design methodology. Data collection: Semi-structured interviews. Data analysis: Thematic analysis.	Adult smokers/ex-smokers with mental diseases (N = 12), 8 males, 4 females.	Kick.it Sources: An analysis of literature combined with stakeholder input from health professionals and smokers, using intervention mapping development framework	YES	Users liked the app: 1. Provided the in-time strategy messages; 2. The tracking function which could provide them with ongoing feedback; 3. Had a chat room so that they could connect likeminded people; 4. The inclusion of terms and conditions that outlined the privacy settings and rules of use to alleviate potential concerns around engaging with the social network. Users disliked the app: Difficult to navigate the app because of limited knowledge and skills in technology. Users wanted the app to cover: 1. Tailored to an individual’s psychological needs; 2. Normalised smoking relapse and multiple quitting attempts; 3. A caring app which could offer companionship and enable them to share their concerns without feeling stigmatized or judged; 4. To be social network based.
11	Luna-Perejon et al. [24]/ Spain	Aim: To evaluate the user experience, and more specifically the usability and the user satisfaction with the app. Setting: University.	Design: Cohort study. Data collection: Questionnaire and expert report. Data analysis: Not reported.	Experts (N = 25), 11 females and 14 males. Adult smokers (N = 45), gender was not reported	So-Lo-mo Sources: The app was designed in the EU SmokeFreeBrain project	YES	Users disliked the app: 1. The game menu was difficult to find; 2. Games were boring, too simple, and with no option to pause; 3. The audio-visual functions needed to be improved. Users liked the app: It was easy to use.
12	Maramis et al. [25]/ Finland	Aim: To present the development of QuitIT! As well as its preliminary evaluation. Setting: Not reported.	Design: Qualitative evaluation design. Data collection: Interviews. Data analysis: Not reported.	Adult smokers (N = 15), 9 males and 6 females.	QuitIT! Sources: The design of this app followed an iterative user-centered design methodology and incorporated social influence techniques	YES	Uses wanted the app to cover: 1. Adding a function for inviting friends to QuitIT! via personal messages in social media; 2. Can customise the timing of the end-of-day reporting alert.

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Table 3 (continued)

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
13	Meijer et al. [28]/ Netherlands	Aim: To evaluate StopCoach and to explore the experience of smokers using StopCoach. Setting: Blended care settings within five municipalities in The Netherlands.	Design: Mixed-methods design. Data collection: Semi-structured interviews. Data analysis: Framework Analysis.	Lower socio-economic status (SES) smokers (n = 22); Sex ratio was not reported.	StopCoach Sources:	YES	Users liked the app: 1. Easy to install and use; 2. The design and layout was positive; 3. The descriptive statistics; 4. Providing virtual coach to give supports; 5. Providing practical information and tips.
14	Naughton et al. [30]/ UK	Aim: 1. Assess smokers' compliance with reporting their smoking in real time and identify reasons for noncompliance; 2. Assess the app's accuracy in identifying user-specific high-risk locations for smoking; 3. Explore the feasibility and user perspective of geofence-triggered support; 4. Identify any technological issues or privacy concerns. Setting: Not reported.	Design: An explanatory sequential, mixed-methods design. Data collection: Interviews. Data analysis: Thematic analysis.	Adult smokers (N = 15), 7 females, 8 males.	Q Sense Sources: Researchers investigated the barriers and facilitators of user engagement with the app through mixed-methods designs and learn about its support delivery system under natural conditions	YES	Users liked the app: 1. Locations of their smoking reports as recorded by Q Sense as correct and accurate; 2. The way the app used location sensing (eg, GPS and Wi-Fi); 3. Geofence messages were useful in providing distractions or alternatives to smoking; 4. Morning support messages were also described as being a helpful motivation boost. Users wanted the app to cover: 1. Had shorter messages, suggestions of alternatives to smoking, and messages tailored to the situation; 2. Concerned about the privacy; 3. Had the option to set a new quit date; 4. Enabling user preferences for the types of messages provided (e.g., health information and motivational message); 5. Had cartoons or videos as well as text support; 6. Had a "human" element within the app, to link in with a support network or a stop-smoking advisor or service.
15	Paay et al. [31]/ Denmark	Aim: To explore how participants, smokers and ex-smokers, interacted with the different content types and sources of Quitty. Setting: University.	Design: Qualitative exploratory design. Data collection: Semi-structured interviews. Data analysis: Opening coding method from grounded Theory.	Adult smokers or ex-smokers (N = 11), 8 males, 3 females.	Quitty Sources: Researchers were guided by Fogg's principles for persuading people into behaviour change using technology and incorporated findings from literature to design the app	YES	Users wanted the app: 1. Messages were generated from a real person; 2. Messages did not arrive at the same time each day; 3. Messages should be funny and not repetitive; 4. Messages should have a link to the app; 5. Users preferred gain-framed messages; 6. Had genuine and realistic content; 6. Tips should suggest ways to get healthy again and make original content; 7. Had positive motivator since it helped users to focus on possible achievements; 8. Adding social functionality in the app. Users disliked the app: 1. Did not provide enough content both in terms of the amount released each day; 2. Lacked depth in the information to keep them interested in using it on a daily basis.
16	Paay et al. [32]/ Denmark	Aim: To discuss participants' experience with the app and the role	Design: Qualitative descriptive design.	Adult smokers or recently quit but want	QuittyLink	YES	Users liked the app: 1. Was easy to use; 2. Users were interested in the

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Table 3 (continued)

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
		it played in their smoking cessation. Setting: Not reported.	Data collection: Semi-structured interviews. Data analysis: Not reported.	to stay quit (N = 13), 4 males and 9 females.	Sources: Researchers designed the app based on previous studies on health behaviour change and smoking cessation, and the review of existing apps		tracking function; 3. Users found the app helped them to reflect on their smoking patterns and cigarette consumption; 4. Had a visual representation of their smoking habit; 5. The counselling messages were personalised and written specifically for them and their current situation; 6. The “resisted” function was useful in keeping their motivation high.
17	Paay et al. [33]/ Denmark	Aim: To gain smokers’ and ex-smokers’ attitudes towards quitting, and their ideas about how interactive technology might be used to help them quit. Setting: Not reported.	Design: An empirical investigation. Data collection: Focus group and design workshops. Data analysis: Thematic analysis.	Adult smokers or ex-smokers aged from 20 to 61 (N = 18), 11 males and 7 females.	QuitNow-My Quitbuddy Sources: N/A	NO (A commercial app)	Users wanted the app: 1. Flexibility: to be flexible enough to adapt to the user’s current needs; 2. Reminders need to be sent out when and where a smoker tends to crave cigarettes to avoid making them think about smoking; 3. Self-monitoring could be used to help people understand their own smoking habits and create strategies to cope with cravings; 4. Visualizations of smoking behaviours, calculated compensations in the form of financial or health gains, or stories and tips tailored to a person’s behaviours; 5. Novelty: Presenting people with new and surprising information attracts attention and sparks interest; 6. Had meaningful rewards: need to be something that holds value and meaning for that person; 7. Had social support; 8. Competition: Participants felt that it was highly motivational to be involved in competition; 9. Showed losses and gains.
18	Paay et al. [34]/ Denmark	Aim: To explore how smokers responded to entering data about their smoking habits and then receive personal counselling advice. Setting: Not reported.	Design: Qualitative evaluation design. Data collection: Semi-structured interviews. Data analysis: Content analysis.	Adult smokers aged from 22 to 52 years old; 4 males and 9 females (N = 13).	QuittyLink Sources: Researchers designed the app based on previous studies on health behaviour change and smoking cessation, and the review of existing apps	YES	Users liked the app: 1. Can learn their smoking patterns (time and place); 2. An informative picture to show their smoking behaviours; 3. Can track their smoking habits; 4. Easy to use; not too time-consuming; 5. To send reminders to remind them to use the app; 6. Have convenient and pertinent counselling; 7. The counselling messages were personalised; 8. Made them reflect more on their habits, potentially inspiring future behaviour change. Users wanted the app: 1. They can choose the timeframe of the graphs

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Table 3 (continued)

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
							and can compare the smoking behaviours with last weeks; 2. Convenient and pertinent mobile counselling: users preferred the convenience of receiving counselling on their mobile phone rather than having to contact someone.
19	Peiris et al. [35]/ Australia Australian and New Zealand Clinical Trials Registry ACTRN12616001550493	Aim: To assess the feasibility and acceptability and explore the effectiveness of a novel mHealth app to assist Aboriginal people to quit smoking. Setting: Community.	Design: A pilot randomised controlled trial (RCT) plus process evaluation. Data collection: A questionnaire and semi-structured interviews. Data analysis (interview only): Thematic analysis using a context-mechanism-outcome (CMO) configuration.	RCT: 49 smokers (intervention group = 25, control group = 24), 38 females and 11 males, mean age = 42 years old Interviews: 15 participants from intervention group.	Can't even Quit Sources: Researchers reviewed the existing smoking cessation apps first, then gathered user groups to get their opinion.	YES	Users liked the app: 1. Game apps could provide a stronger motivation for engaging in health apps; 2. Value of a group atmosphere to support smoking cessation was mentioned. Users wanted the app: 1. Not too difficult to use; 2. Had a balanced message frequency; 3. Had personalised messages; 4. To incorporate games; 5. To be more social, interactive, and inclusive of user-generated content.
20	Rusu et al. [38]/ Romania	Aim: To explore the views of postpartum women on the two components of the Stay Quit Together prevention intervention – the iCoach mobile application and the text messages. Setting: Obstetrics and gynaecology clinic.	Design: Qualitative exploratory design. Data collection: Semi-structured interviews. Data analysis: Thematic analysis.	Women who just gave birth, have tried quitting before or during pregnancy (N = 12).	iCoach Sources: N/A	YES	Users liked the app: The panic advice and daily advice were useful. Users disliked the app: 1. There was too much text and suggested more images; 3. The most useful functions were panic advice and the daily advice.
21	Smith et al. [42]/ Australia	Aim: To examine what influenced people to engage or disengage with the app, and how the app was deployed in quit attempts. Setting: Not reported.	Design: A qualitative exploratory design. Data collection: interviews. Data analysis: thematic analysis.	Adult smokers who have an attempt to quit (N = 23), 11 males and 12 females.	Newleaf Sources: Researchers designed the app based on a previous study and the Reddit website	YES	Users liked the app: 1. Had authentic and contextualised stories; 2. Stories had specific advice that was contextualised. Users wanted the app: 1. Valued their anonymity; 2. Selecting stories that fitted their stage of quitting and which they could relate to and use productively.
22	Struik et al. [45]/ Canada	Aim: To contribute insights toward understanding how young adults interact with the smoking cessation app and how this interaction shapes young adults' smoking cessation experience and practices. Setting: Not reported.	Design: Qualitative case study. Data collection: Semi-structured interviews. Data analysis: Framework approach.	Young adult smokers (N = 31), 13 females and 18 males.	Crush the Crave Sources: The design of this app was underpinned by the US Clinical Practice Guidelines for quitting smoking and principles of persuasive technology for behaviour change	YES	Users liked the app: 1. The credibility component of CTC played an important role in harnessing the trust of young adults; 2. The tracking function were helpful; 3. By providing tailored information about the health benefits of quitting smoking countered some optimism bias in relation to the predicted effects that smoking had on them; 4. Visibility of their efforts (awards) was helpful in motivating users continuing quitting smoking.

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No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
23	Struik et al. [44]/ Canada	Aim: To detail how the overall design approach of Crush the Crave (CTC), a quit smoking app that targets end-users, compares with young adult women's and men's perspectives and experiences, with consideration for the influence of gender. Setting: Not reported.	Design: Qualitative case study design. Data collection: Semi-structured interviews. Data analysis: Thematic analysis.	Young adult smokers (N = 31), 13 females and 18 males.	Crush the Crave Sources: The design of this app was underpinned by the US Clinical Practice Guidelines for quitting smoking and principles of persuasive technology for behaviour change	YES	Users disliked the app: 1. The social support component was regarded as the weakest function to assist users to quit smoking; 2. The Quit Buddy function was unsuccessful; 3. A gradual quit plan was unproductive since young smokers wanted to quit abruptly. Users liked the app: 1. Fit with needs and preferences of their age groups; 2. Integrating the app with social media platforms enabled easier access and opened opportunities to reach young adults with cessation support; 3. The content was delivered in a fun and positive way; them into an app for users to support self-management of health behaviour; 4. The underlying focus in the design of the app was the individually-led nature of the intervention; 5. Easy to use. Users disliked the app: 1. The app was too dark; 2. Had so many subpages which led to "hidden" functions they were unaware of; 3. Some app functions were based on the quit date, which sometimes led to inaccurate statistics. Users liked the app: 1. Not difficult to use; 2. Can monitor how much they smoked and their improvements through visual feedback; 3. The app was not difficult to use; the 'logging'; 4. Can know the place and time of smoking; 5. The spatial representation of smoking. Users disliked the app: 1. The 'logging' function often diverted attention and delayed smoking; 2. Cannot see other users' comments; 3. Do not have a chat room; 4. Too much reminding to trigger a craving. Users liked the app: 1. To be personalised; 2. Had the 'sharing', 'saving', and 'tips' functions; 3. Had a positive and bright color scheme; 4. Easy to use and not too time-consuming; 5. To be interactive; 6. Had audio files; 7. Information was delivered concisely, and beyond what the users expected and knew; 8. Considered privacy; 9. The
24	Schick et al. [40]/ UK	Aim: To evaluate the app as a potential smoking cessation aid and explore user experience and technological requirements and security of the data flow. Setting: NHS Fife GP practice.	Design: Pre- and post-quit two-phase design. Data collection: Two face-to-face interviews, and one telephone interview. Data analysis: Not reported.	Adult smokers who are interested in smoking cessation (N = 8), gender was not reported.	MapMysmoke Sources: N/A	YES	Users disliked the app: 1. The 'logging' function often diverted attention and delayed smoking; 2. Cannot see other users' comments; 3. Do not have a chat room; 4. Too much reminding to trigger a craving. Users liked the app: 1. To be personalised; 2. Had the 'sharing', 'saving', and 'tips' functions; 3. Had a positive and bright color scheme; 4. Easy to use and not too time-consuming; 5. To be interactive; 6. Had audio files; 7. Information was delivered concisely, and beyond what the users expected and knew; 8. Considered privacy; 9. The
25	Tudor-Sfetea et al. [48]/ UK	Aim: To explore participants' perceptions of 2 mHealth apps, a CBT-based app, Quit Genius, and a non-CBT-based app, NHS Smokefree, over a variety of themes; investigate the perceptions and health behavior of users of each app with respect to smoking cessation. Setting: not reported.	Design: A qualitative short-term longitudinal study. Data collection: Semi-structured interviews. Data analysis: Thematic analysis.	Adult smokers who are intended to quit (N = 29), 25 males and 4 females.	Quit Genius/ NHS Smokefree Sources: N/A	NO (Downloaded from App Stores)	Users disliked the app: 1. The 'logging' function often diverted attention and delayed smoking; 2. Cannot see other users' comments; 3. Do not have a chat room; 4. Too much reminding to trigger a craving. Users liked the app: 1. To be personalised; 2. Had the 'sharing', 'saving', and 'tips' functions; 3. Had a positive and bright color scheme; 4. Easy to use and not too time-consuming; 5. To be interactive; 6. Had audio files; 7. Information was delivered concisely, and beyond what the users expected and knew; 8. Considered privacy; 9. The

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Table 3 (continued)

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
							<p>“context behaviour therapy” method contributed to their intrinsic motivation to quit.</p> <p>Users disliked the app: 1. The ‘lapse’ function; 2. Lacking interactivity caused boredom and a decreased desire to use the app; 3. Lacking human contact from a physician.</p> <p>Users liked the app: 1. Can help them to explore their own smoking journeys and was valuable in understanding psychological triggers and cues of why they smoked and re-evaluate their smoking behaviour; 2. Increase their confidence and improve their willpower.</p> <p>Users wanted the app: 1. Had more personalised functions, such as customised motivation scales or tailoring tips; 2. Audio clips should be shorter and more concise, videos should be available for text-heavy topics; 3. Social interaction function should be reinforced; 4. Gaming aspects would be an aspiring function; 5. Adding more visualization, such as a graphical representation monitoring health; 6. Providing regular health news updates such as smoking taxes and bans.</p>
26	Vilardaga et al. [49] / USA	<p>Aim: To evaluate user experience of the app amongst people with serious mental illness.</p> <p>Setting: A community mental health clinic.</p>	<p>Design: Qualitative evaluation design.</p> <p>Data collection: Questionnaire, Semi-structured interviews, Think aloud procedure, Daily diary.</p> <p>Data analysis: Affinity diagram, a grounded field theory approach.</p>	Adult smokers who take psychiatric medication as prescribed (N = 5), 5 males.	<p>Quitpal</p> <p>Sources: The app design was based on US Clinical Practice Guidelines for smoking cessation</p>	YES	<p>Users disliked the app: 1. Needed guidance to use it; 2. They needed to wait a whole day to press the ‘I was smoke free today’; 3. Not intuitive; 4. They were easy to forget press the ‘save’ button when they smoked; 5. The number of layers and steps to accomplish tasks was excessive.</p> <p>Users wanted the app: 1. Focused more on the process of cutting down, not quitting; 2. Had nonmonetary rewards; 3. Used the cognitive-behaviour-therapy skills; 4. Adding motivating functions, such as gaming components.</p> <p>Users liked the app: 1. Learn to Quit was easy to use; 2. Gamification in Learn to Quit can engage users in it; 3. The tracking chart in QuitGuide was useful and desirable.</p>
27	Vilardaga et al. [50]/ USA	<p>Aim: 1. To report the results of a series case studies testing the usability, user experience (UX), and user engagement (UE) of LTQ; 2. To explore whether LTQ and QG differ in terms of UX and in what way they</p>	<p>Design: Case studies.</p> <p>Data collection: System usability scale, UX interviews and background analytics.</p> <p>Data analysis: Thematic analysis.</p>	Adult smokers with serious mental health diseases, who have an intention to quit (N = 7), 4 females and 3 males.	<p>Learn to Quit/ QuitGuide</p> <p>Sources: LTQ was designed based on Acceptance and Commitment Therapy.</p>	YES	<p>Users liked the app: 1. Learn to Quit was easy to use; 2. Gamification in Learn to Quit can engage users in it; 3. The tracking chart in QuitGuide was useful and desirable.</p>

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Table 3 (continued)

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
		were similar or different. Setting: Mental health clinic.			QG was designed based on US Clinical Practice Guidelines for smoking cessation		Users disliked the app: 1. QuitGuide was not intuitive and was difficult to access app functions; 2. QuitGuide had a 'serious' look and feel. Users wanted the app: 1. Adding a self-initiating tracking function; 2. A wider variety of automated messages in response to self-reported levels of mood or cravings 3. Stronger integration of the tracking function with LTQ modules to increase the personal relevance of the self-tracking function and increase retention and comprehension of theory-based content. Users wanted the app: 1. The colour, font type and visuals to be appealing; 2. Adding an option for customisable colours; 3. Adding a pedometer to facilitate physical activities; 4. The content of various app functions should be updated on a daily basis; 5. The app content to be personalised enough.
28	Wu et al. [56]/ UK	Aim: To explore pregnant smokers' views on the design, content and usability of a pregnancy-specific smoking cessation app in order to inform intervention development and optimisation. Setting: Stop-smoking clinics and pregnancy-specific forums.	Design: Qualitative exploratory design. Data collection: Interviews. Data analysis: Thematic analysis.	Pregnant smokers (N = 10), 10 females.	SmokeFree Baby Sources: The app design was informed by the Multiphase Optimisation Strategy, the UK Medical Research Council guidance, the Behaviour Change Wheel, the COM-B model of behavior, the plans, responses, impulses, motives, evaluations (PRIME) theory of motivation, evidence from the scientific literature, and behavioural change techniques (BCTs) from the BCT Taxonomy v1.2	YES	Users liked the app: 1. Easy to navigate; 2. Interactive; 3. Various ways to present contents (such as quizzes and videos); 4. Presenting tips in shorter segments rather than long lists; 5. Provided educational information they did not know previously; 6. Monitoring the number of smoke-free days could help them maintain their motivation to remain abstinent.

smoking cessation app was a concern in some studies [30,42,21,38]. Users were worried about the safety of their data [38], or valued anonymity when using the app to quit smoking as this made them feel safe [42]. Interestingly, in Naughton et al. [30], some participants were not concerned about app privacy as the study was affiliated with a university, rather than a commercial company.

4. Discussion

4.1. Principal findings

To our best knowledge, this is the first qualitative systematic review to explore smokers' experience of using smoking cessation apps. The 28 studies revealed six key app functions: education, tracking, social support, compensation, distraction, and reminding; and five key app characteristics: simplification, personalisation, diverse contents formats, interactivity, and privacy and security. The most frequently mentioned app functions were tracking ($n = 21$ studies) and social support ($n = 19$), while the most frequently discussed app characteristics were simplification and personalisation with 18 and 17 studies mentioned them, respectively.

4.2. Comparison to existing literature

Regmi et al. [36] identified eight studies in which mobile apps helped increase the quitting rate among smokers. All studies adopted behaviour change theories. Audio-visual functions followed by a quit plan, tracking progress, and sharing functions were the most accepted and utilised. Functions which increased app engagement were statistically significant in increasing the quitting rate and apps which used social media appeared to reduce relapse to smoking. This suggests that the functions and characteristics highlighted in this review might be beneficial for smoking cessation.

Consistent with this review, Xu et al. [57] found that smokers rated the following four app functions as very or extremely important: social support, tracking, personalisation, and helping to cope with withdrawal symptoms, which is reflected in the sub-themes of distraction and education. Security and privacy were rated less important than other app functions.

McClure et al. [27] found that five app aspects were important to both health care providers and smokers: low cost, personalisation, tracking, privacy, and helping to manage withdrawal symptoms and medication side effects. Privacy was rated as the most important function among health care providers, while smokers thought personalisation was paramount. Gaming and social media connectivity were regarded less important than other app functions. In this review, we found that gaming and gamification underpinned the functions of distraction and compensation. Privacy preserving social support is important, which explains the reduced importance of social media connectivity. There is a need to explore whether willingness to use social support function is associated with specific populations and the possible benefits and security concerns [8].

It is important to encourage users to use smoking cessation apps as a tool to support smoking cessation, along with other smoking cessation methods, rather than relying on it as a sole source of distraction or support. While some components of smoking cessation apps, such as games, might be addictive, there was no evidence of this in the studies in the review. However, some studies found that excessive mobile gaming can lead to negative consequences, including impaired social functioning, disrupted sleep patterns, and poor academic performance [19] and Lopez-Fernandez et al. [23] found a significant proportion of participants reported feeling anxious or irritable when unable to access their mobile phones, which highlights the potential for mobile gaming to become a problematic behaviour and the need for further research to explore how to avoid addiction when using mobile games within apps.

A recent meta-analysis examined the relative effectiveness of mobile

applications compared to other forms of smoking cessation interventions [6]. It remains to be seen whether the effectiveness of apps can be improved by better design that is more responsive to the needs of users.

4.3. Implications for future work

The results of this review can be used to guide app developers to design smoking cessation apps which can better meet smokers' needs: In terms of app functions, smoking cessation apps should (1) help users track the time, location, and intensity of smoking cravings (2) enable users to connect with others who are trying to quit smoking, share their experiences, and provide mutual support, (3) provide up-to-date, evidence-based health education on the benefits of smoking cessation, risks of smoking, and tips for managing cravings, (4) provide various methods to distract users from cravings, such as music, videos, mini-games etc., (5) provide gamification such as virtual rewards and visualisations to motivate users, emphasising quitting days, money saved, health recovery status etc. to boost their self-efficacy, (6) offer tools such as goal setting and reminders to keep users motivated and engaged. These functions could be co-designed with people of different ages, genders, ethnicities, and other characteristics to ensure how smoking cessation apps work are tailored appropriately for a wide variety of users. In terms of app characteristics, (1) the software interface should be intuitive and easy to navigate, (2) users should be able to adapt apps to their habits, preferences, and goals, (3) apps should add interactive components to increase engagement, (4) apps should use various media, such as video, audio, infographics or images, to replace long texts, (5) apps should be compliant with data privacy laws and have robust security measures to protect users' personal information.

Further research could link the findings of this study with the findings of studies that examined smokers' attitudes toward, and reasons for smoking to develop a programme theory to explain how and why smoking cessation apps are expected to work, which could provide valuable information for evaluation of such programmes.

All included studies were conducted in high-income countries. Yet, globally, over 80% of the smoking population live in low- and middle-income countries, where the morbidity and mortality of smoking-related diseases are highest [55,54]. There is a clear need for research exploring smokers' experiences of smoking cessation apps in these contexts, where tobacco policy, accessible smoking cessation services, Internet access, mobile phone ownership, and smoking culture may be very different.

It is worth noting that app-based smoking cessation programmes are primarily accessible for smokers who are comfortable with using smartphones and can afford Internet access required by many apps to send or receive data. Policy makers and health providers working in smoking cessation need to consider to what extent app-based approaches are suitable for people from low-income households, people who live in areas with poor Internet connectivity, and those who are not comfortable with using technology as their digital literacy knowledge and skills are low [41,26]. In addition, apps need to be designed to be accessible for people with dexterity or vision impairment. Accessibility was not assessed in this systematic review given that we focused on reports of the user experience. Furthermore, those living in low- and middle-income countries may have no or limited access to mobile phones and the Internet which could prevent them from utilising smoking cessation apps [53].

4.4. Limitations

This review has several limitations. Firstly, grey literature on this topic was excluded. Since we did not conduct a separate quality assessment, we ensured that studies had at least been vetted by peer review. Papers were limited to those written in English. Secondly, although every effort was made to follow the inclusion criteria, one included study recruited smokers over 16 years of age, but the youngest

Table 4
Frequency of app function and app characteristics related themes in the data set.

No./Author (Year)	High-Level Theme 1: App Functions						High-Level Theme 2: App Characteristics				
	Education	Tracking	Social Support	Compensation	Distraction	Reminding	Simplification	Personalisation	Diverse output forms	Interactivity	Privacy and Security
1. Armin et al. [2]		✓		✓					✓		
2. Baskerville et al. [4]		✓	✓	✓	✓			✓			
3. Bendotti et al. [5]	✓	✓	✓		✓	✓	✓	✓		✓	
4. El-Hilly et al. [11]	✓	✓	✓				✓	✓			
5. Edwards et al. [10]	✓			✓	✓			✓		✓	
6. Fulton et al. [13]							✓		✓		
7. Gowarty et al. [15]	✓	✓	✓	✓	✓	✓				✓	
8. Gowarty et al. [16]		✓	✓	✓	✓	✓	✓				
9. Herbst et al. [18]	✓	✓	✓	✓	✓	✓	✓		✓	✓	
10. Klein et al. [21]		✓	✓				✓	✓			✓
11. Luna-Perejon et al. [24]	✓			✓	✓	✓	✓	✓			
12. Maramis et al. [25]		✓					✓	✓			
13. Meijer et al. [28]	✓	✓					✓				
14. Naughton et al. [30]		✓	✓			✓	✓	✓	✓		✓
15. Paay et al. [31]	✓	✓	✓			✓	✓	✓		✓	
16. Paay et al. [32]		✓	✓	✓			✓	✓			
17. Paay et al. [33]	✓	✓	✓	✓	✓	✓	✓	✓		✓	
18. Paay et al. [34]		✓	✓			✓	✓	✓			
19. Peiris et al. [35]			✓		✓	✓	✓	✓		✓	
20. Rusu et al. [38]	✓						✓		✓		✓
21. Smith et al. [42]	✓		✓		✓		✓			✓	✓
22. Struik et al. [45]		✓	✓	✓	✓	✓		✓		✓	
23. Struik et al. [44]	✓	✓	✓	✓			✓	✓		✓	
24. Schick et al. [40]		✓	✓			✓	✓	✓		✓	
25. Tudor-Sfetea et al. [48]	✓	✓	✓		✓	✓	✓	✓	✓	✓	
26. Vilardaga et al. [49]		✓		✓		✓	✓	✓		✓	
27. Vilardaga et al. [50]		✓			✓		✓	✓		✓	
28. Wu et al. [56]	✓		✓		✓		✓	✓	✓	✓	
Total	14	21	19	12	13	14	18	17	7	14	4

Table 5a

Illustrative quotes (examples) from included studies to support the App Functions theme.

Subtheme 1: Education

"I... enjoy learning something new. It's quite informative and makes you think about what you're doing. [QG] helps you to understand a bit more about what's going on...what could go wrong by continuing (to smoke)" [48]

"Maybe it could give you an explanation of how your health is improving." [10]

Subtheme 2: Tracking

"So, I think maybe on the app if you can track maybe with a different graph, what time you normally get a craving or if you do get one just to maybe log it and so you can see when they get stronger or when they get weaker." [18]

"I found out that I smoke the most at home and when passing time...I always thought that if I smoked, it was because I was stressed. So my justification to smoke is not really honest." [34]

"I don't necessarily count the days, but then I can perhaps with a tracker go 'Oh it's been nine days and twelve hours! This is great! I feel better now, it felt like it was only two days!'" [31]

"I thought I knew how much I was smoking but this [smoke button] gave me a reality check.....it was neat to see how much I was actually smoking" [45]

Subtheme 3: Social support

"Don't want to share progress on social media in case you fail." [48]

"So I think if you could, like, message someone on the app that's using it at the same time...if you could communicate with someone else using it, like chat with them..." [15]

"I can imagine this would help quite a lot: talking to ex-smokers about what helped them quit and then all different sections [in the 'Identity' module]. This is really good, because I think you need communication with other people who have gone through the same situation as you to make you feel like you are not alone" [56]

"You'd have each other to lean on and to express what you're feeling" [35]

"It's like relating your experiences to theirs and trying to find what you can do about it" [42]

"It is like a game, where you always gain new levels, and when you take a cigarette you lose levels. Then it is like 'Ah crap'... I want to win this competition against others and for how long can I keep off the smokes compared to others?" [33]

Subtheme 4: Compensation

"It was nice to track ... the average of how much you would spend, and a big function at the top is how much you saved ... it's visual and lets you know, lets the user know how much did I really save and am I making progress." [18]

"My reward should be bigger than how delicious I think it is to smoke." [33]

"Cigarettes are rewarding to us, physically and psychologically, they're rewarding.... Give me the reward, man! ...I quit [smoking]" [2]

"I couldn't actually log how many cigarettes and stuff I had ...[so] it's not accurate. But if it was accurate it [would be] cool to see like, you know, money saved, like, oh hey, I saved \$100 smoking so far. Like you know, it's something to be proud of" [44]

"After a week if would be good to tot up how much money you have saved." [10]

Subtheme 5: Distraction

"It helped me cope with stress in the sense that it distracts me ... always something in your hands with the app ... I mean it does help with stress." [18]

"Maybe if they had prior to like some type of like a mini game or something in there that would keep the mind occupied rather than telling you, 'Don't smoke.'" [48]

"I am craving so idea of a craving button which could be pressed when needed and links to a page with different management strategies e.g., play game, prompt to go for walk, speak to friend." [10]

"cause when you're having a craving, you just look at it [the app] and maybe it'll tell you, like, uh, go for an hour run, or you know, tell you some sort of structure to keep your mind off of you smoking. Something to keep you busy, keep your hands busy..." [15]

Subtheme 6: Reminding

"I would definitely say the motivation that it would give you, because it's like a set time—twelve o'clock you set it, and it'll say, 'Good job you didn't smoke today.' ... And even if you did smoke, it'll give you like the drive to quit smoking—maybe you'll feel bad in your mind if you did smoke and the message said that you didn't." [18]

"I was getting texts all the time, reading all of them, trying to take in all the information...They were good...motivating, especially when you're having a hard day and you get texts all the time, and it's like, 'Yeah, I can do it.' ..." [35]

"I liked how it gave notifications, like every day I've got a notification saying; You're on day four of your smoking quitting history." [48]

"It must not remind people of having a smoke. Enough is doing that already. If I had an app that kept giving me messages, I would just think 'I could really use a cigarette right now'" [33]

"These were good reminders. So, if I did not check it that day so it was like 'oh yeah that's what I have to do'. Because you do forget especially if you are busy or you are tired." [31]

Table 5b

Illustrative quotes (examples) from included studies to explain the theme App Characteristics.

Subtheme 1: Simplification

"Easy and fast. It takes a quarter of a second to open and then you just press save and 'bang', you are done" [34]

"It was easy to get to, easy to use. Especially like being a mom...it was easy and simple. It wasn't overly complicated—like to start, like the start-up was [easy to] enter stuff...it wasn't overly long...[My son] only lets me use my phone for like two seconds at a time" [44]

Subtheme 2: Personalisation

"It means a lot that it was written specifically to me, what I should do, and not what others should do" [34]

"Being personalized is definitely important." [10]

Subtheme 3: Diverse content formats

"There is too much text. There should be more images" [38]

Subtheme 4: Interactivity

"It just needs to be made more interactive." [48]

"It has to be interactive to work." [10]

"I quite like the quiz. It's very interactive, which is really good and it helps you learn more about what you are actually doing to your body and to your baby's body without actually doing it in a patronising way" [56]

Subtheme 5: Privacy and Security

"The safety of the program - the personal data, so nobody can access it" [38]

participant's age cannot be found [35]. We decided to include this study in our review because we believe that it contained rich and relevant information that was valuable for answering the research question. Regarding the interpretation and discussion of the findings, we took into consideration the age distribution of the participants when conducting our analysis and interpreting the results. Thirdly, we conducted a qualitative content analysis of summarised findings and key quotes that focused on the apps themselves, and not on the context in which they were used. This would require a more in-depth thematic analysis of the full results and discussion sections of all papers. Fourthly, because of the heterogenous nature of included papers and the contested nature of using a structured approach to assess the quality of qualitative and mixed-method research papers [9,37], we did not assess the risk of bias. Finally, due to the qualitative nature of this review, we did not assess for publication bias.

5. Conclusion

In this systematic review of the qualitative evidence on the user experience of smoking cessation apps, we determined six key app functions and five key app characteristics that may play a role in the success of mHealth for smoking cessation. In addition to informing the design of new smoking cessation apps which better meet smokers' needs, our findings can also be used as the basis for planning realist evaluation research of specific apps and creating programme theories that link behaviour change with technology use.

CRedit authorship contribution statement

Mengying Zhang: conceptualisation, data curation, formal analysis, writing - original draft. **Dr. Maria Wolters:** conceptualisation, data curation, validation, writing - review & editing. **Yajing Wang:** data curation. **Dr. Siobhán O'Connor:** conceptualisation, data curation, writing - review & editing. **Dr. Lawrence Doi:** conceptualisation, data curation, validation, writing - review & editing.

Funding

This work did not receive external funding.

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.

Acknowledgement

We would like to acknowledge Rowena Stewart, the librarian at the School of Health in Social Science, The University of Edinburgh for her assistance with the search strategy.

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