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# **The use of smoking cessation applications in China: A realist evaluation**

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# Abstract

**Background:** The epidemic of tobacco use has posed huge challenges to global public health. Consequently, tobacco control is crucial in achieving the United Nations Sustainable Development Goal 3 (good health and well-being). Smoking, as one of the most prevalent forms of tobacco use, is a leading cause of preventable morbidity and mortality worldwide. One measure of tobacco control is launching smoking cessation programmes, which have been recognised as an effective method to support individuals in quitting smoking. Smoking cessation programmes can be delivered through various approaches, including mobile applications (apps). According to the most updated data of the World Health Organization in 2024, China is the world's largest producer and consumer of tobacco, with over 30% of worldwide smokers coming from China. Given the high penetration rate of mobile phones in China, smoking cessation apps have great potential to assist Chinese smokers to stop smoking. Although the effectiveness of mobile health interventions in smoking cessation has been established by previous research, there is still a lack of research exploring how smoking cessation apps work.

**Aim:** This study aims to examine what aspects of smoking cessation apps work for Chinese smokers, under what circumstances, and how.

**Methods:** The study employs the realist evaluation methodology and is composed of three stages. In stage one, two separate systematic reviews and six semi-structured interviews with Chinese health workers working in the field of smoking cessation were conducted to formulate initial programme theories (IPTs) in both the forms of 'if...then...because...' statements and Context-Mechanism-Outcome Configurations (CMOCs). In stage two, 24 semi-structured interviews were conducted with Chinese smokers who have experience using smoking cessation apps to test the IPTs. Stage three involved realist refinement of the IPTs leading to the development of refined programme theories, which proceeded by comparing the data with initial CMOCs deductively and identifying new constructs of programme theories inductively. The refined programme theories were presented in the form of CMOCs. Across this study, all semi-structured interview data were analysed using the thematic analysis

approach. Ethics approval for the study was obtained from the University of Edinburgh.

**Findings:** In the context of being motivated to stop smoking and perceiving smoking cessation apps as a useful tool, smokers reported that engaging with the app features that tracked quitting achievements and health gains and showed the risks of smoking boosted their motivation and self-efficacy in smoking cessation, therefore supporting long-term abstinence.

Social features within apps provided crucial informational and emotional support, proving particularly beneficial for smokers seeking social support. Engaging with the social features enhanced their motivation, confidence, and self-esteem, although poor management and regulation of these social platforms within apps can lead to reduced engagement and affect the support necessary to quit smoking.

Although the withdrawal symptoms management features were intended to increase smokers' skills to cope with withdrawal symptoms and clarify their craving patterns, the engagement level of these features was low. For those smokers who need the skills to prevent relapse and seek support within apps, the low intensity of intervention that lacks further guidance and personalisation may deter continuous use.

This evaluation also found that good usability and user experience could boost user engagement levels, therefore improving smoking cessation outcomes.

**Conclusion:** This evaluation has generated explanations of the use of smoking cessation apps among Chinese smokers. The programme theories can be useful resources for app developers to design apps that better meet user needs to help them recover from addictive behaviours.

# Lay Summary

Tobacco use is a major global health issue, leading to numerous preventable illnesses and deaths. One effective way to solve this problem is through smoking cessation programmes, which help smokers quit smoking. These programmes can be delivered through various means, including mobile applications (apps). China has a significant portion of the world's smokers. With the widespread use of mobile phones in China, smoking cessation apps hold great potential to help Chinese smokers quit smoking. While previous research has shown that mobile health interventions can effectively assist smoking cessation, there is limited understanding of how these interventions work.

This PhD study aimed to explore how smoking cessation apps work for Chinese smokers by developing and testing programme theories that explain the outcomes of using these apps caused by the interplay between contexts and mechanisms. The study was conducted in three stages using a realist evaluation methodology. In the first stage, I conducted two systematic reviews and interviewed six Chinese health workers to develop initial programme theories (IPTs) about how these apps might work. In the second stage, I interviewed twenty-four Chinese smokers who had used smoking cessation apps to test the IPTs. In the final stage, I refined these theories by comparing the interview data with the initial theories and identifying new elements.

In this study, I found that smokers who were motivated to quit smoking and regarded the apps as useful tools benefited the most. App features that tracked quitting achievements and health benefits increased motivation and confidence in quitting. Social features within the apps provided important informational, emotional support, esteem support, and healthy competition to smokers. However, poor management and regulation of these social platforms could reduce user engagement.

I also found low user engagement made features that were intended to educate withdrawal symptoms management knowledge less effective. Smokers who needed help preventing relapse found that the lack of personalised guidance within the apps deterred continuous use. Additionally, I found good usability and user experience

design were crucial for keeping users engaged and improving smoking cessation outcomes.

In conclusion, this is the first study to explore how smoking cessation apps work to help smokers recover from the tobacco addiction. I hope the findings of this study will provide insights for stakeholders to promote the design of apps that meet user needs better. I also hope more researchers to use realist evaluation to explore how mHealth interventions work to help people recover from addictive behaviours.

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# Abbreviations

App – Application

CAR – Continuous Abstinence Rate

CASP - Critical Appraisal Skills Programme

CDC – Centers for Disease Control and Prevention

CMOC – Context-Mechanism-Outcome Configuration

eHealth – Electronic Health

FCTC – Framework Convention on Tobacco Control

HCI – Human-Computer Interaction

IPT – Initial Programme Theory

LMICs – Low- and Middle-Income Countries

MDGs – Millennium Development Goals

mHealth – Mobile Health

NCDs – Noncommunicable Diseases

NCI – National Cancer Institute

NHS – National Health Services

PAR – Point Abstinence Rate

PMT – Protection Motivation Theory

RCT – Randomised Controlled Trial

SIDS – Sudden Infant Death Syndrome

SDGs – Sustainable Development Goals

SDT – Self-Determination Theory

SEB – Self-Exempting Belief

SMS – Short Message Service

TTM – Transtheoretical Model

UK – United Kingdom

UN – United Nations

US – United States

UX – User Experience

WHO – World Health Organization

## CHAPTER ONE: Introduction

This introduction chapter explains the rationale for this PhD project. It provides an overview of the background of mHealth interventions in smoking cessation, which led to the research aim and questions of this project. At the end of this chapter, an overview of each chapter's contents will be presented.

### 1.1 Rationale for this PhD study?

This PhD research project draws inspiration from two primary sources: the 2016 Chinese College Students' "Internet+" Innovation and Entrepreneurship Competition and my dissertation for the Master's degree completed at the University of Edinburgh in 2019. The Chinese College Students' "Internet+" Innovation and Entrepreneurship Competition is jointly organised by China's Ministry of Education and universities. This competition aims to deepen comprehensive reforms in higher education, stimulate college students' creativity, and cultivate the main force behind "mass entrepreneurship and innovation" (Ministry of Education of the People's Republic of China, 2016). During my undergraduate studies at Huazhong University of Science and Technology in 2016, I participated in this competition and developed a mobile application (app) prototype to help individuals with chronic diseases manage their symptoms effectively (Figure 1.1).



Figure 1.1 Main interface of the app in "Internet+" Innovation and Entrepreneurship Competition

The potential of integrating mobile technology with healthcare sparked my interest and prompted me to explore the possibilities of leveraging this combination. Capitalising on my interest in the role of apps in smoking cessation, existing knowledge base and awareness of the prevalence of tobacco use in China, I made the decision to pursue further research within this field. This is the main reason why I chose mobile health (mHealth) in smoking cessation as my dissertation topic for my Master's degree in 2019.

In pursuit of a comprehensive understanding of the landscape of smoking cessation apps available on the market, I undertook a literature review that scrutinised the functions and characteristics of these mobile apps in my Master's dissertation in 2019. This systematic review was improved by optimising the search strategy, conducting a rigorous systematic search for studies and synthesising them during this PhD study. This systematic review was published in the *International Journal of Medical Informatics* in April 2023 (Zhang et al., 2023). This publication has also been presented in Chapter 4 of this thesis following the guidance of the University of Edinburgh doctoral thesis.

## 1.2 Overview of the literature

Tobacco use is defined as using any form of tobacco plant leaf and its products (Walker et al., 1990). The primary use of tobacco products is through inhaling the smoke of cigarettes, cigars, or pipes (Walker et al., 1990). World Health Organization (WHO) has reported that none of these forms of tobacco are harmless, and there is no safe exposure to tobacco (WHO, 2023a). Tobacco use not only harms almost every organ in the human body (CDC, 2023) but also puts economic pressure on the government to treat smoking-related health problems (WHO et al., 2014). However, research has found that public awareness of the harmful effects of smoking is still insufficient (Szymański et al., 2022, Lee et al., 2022). Therefore, public awareness of the risks of smoking should be strengthened, and there is an urgent need for the implementation of anti-smoking policies, along with various smoking cessation programmes and interventions.

### 1.2.1 Insufficient knowledge of the risks of smoking

Over the past several decades, the harmful effects of smoking on health have been suggested by research (Lakier, 1992, Berger et al., 2009, Braun et al., 2012), including as a major risk factor for cardiovascular diseases (Villablanca et al., 2000, Ambrose and Barua, 2004), respiratory diseases (Jayes et al., 2016, Joseph et al., 2017), and various types of cancer, including lung cancer, gastric cancer (Ladeiras-Lopes et al., 2008), skin cancer (Leonardi-Bee et al., 2012), ovarian cancer (Jordan et al., 2006), bladder cancer (Rink et al., 2015), etc. Additionally, smoking is a significant risk factor for tuberculosis, resulting in a doubling of the likelihood of developing this disease (WHO, 2019b). Furthermore, smoking is linked with maternal and newborn morbidity and mortality. For example, smoking can lead to pre-term labour, spontaneous abortion, and sudden infant death syndrome (SIDS) (WHO, 2017b). The harmful outcomes caused by smoking necessitate early smoking cessation (WHO, 2020a).

Smoking not only poses a threat to smokers' health but also has detrimental effects on non-smokers' health. Research has confirmed the association between second-hand smoke and different health problems among adults (Patra et al., 2015), which include tuberculosis (Dogar et al., 2015), cardiovascular diseases (Dunbar et al., 2013), and stroke (Oono et al., 2011). Furthermore, passive smoking also poses threats to infants' and children's health (Gonçalves-Silva et al., 2006, Treyster and Gitterman, 2011). Research has shown the relationship between passive smoking and attention deficit hyperactivity disorder (Huang et al., 2021) and asthma in children (Vork et al., 2007).

The hazards of smoking have been extensively researched and widely publicised by governmental institutions and non-governmental organisations (CDC, 2020, WHO, 2020a, CDC, 2023). The Framework Convention on Tobacco Control (FCTC) is an international treaty led by the WHO, which was proposed in 2003 and came into force in 2005. The overall aim of FCTC is to implement global health promotion strategies. These strategies include cutting worldwide tobacco supply and demand, protecting the public from secondhand smoke, promoting smoking cessation programmes and offering support services, educating and warning the public about

the risks of smoking, setting restrictions on tobacco advertising and sponsorship, adding tobacco taxation, and supporting international cooperation to address cross-border tobacco issues, to control tobacco prevalence and second-hand smoking exposure and diminish the health and socio-economic impact caused by tobacco consumption (WHO, 2003).

Despite the extensive public health campaigns on the hazards of smoking and the benefits of smoking cessation, public awareness of what exact diseases smoking can lead to remains weak. For example, a study conducted among Polish adults found that although public awareness of the increased risk of developing respiratory diseases, such as lung cancer and chronic obstructive pulmonary diseases, from smoking tobacco is relatively high (92.7% and 89.7%, respectively), there remains a considerable lack of awareness regarding the non-respiratory effects of tobacco use (Szymański et al., 2022). In addition, Sell et al. (2022) also found that among the 411 bladder cancer patients, 44% of them were not sure that tobacco use can increase the risk of developing bladder cancer. The lack of a deep understanding of the negative impacts of smoking on health further emphasises the necessity of developing effective interventions to raise public awareness about quitting smoking and to encourage and assist people in quitting smoking.

### 1.2.2 Smoking Cessation and Sustainable Development Goals

The transition from Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs) was marked in 2015 by the United Nations (UN), presenting the blueprint of the future world by 2030 (WHO, 2015). SDGs contain 17 interconnected goals to achieve a sustainable future for all, which target ending poverty, protecting the planet, and ensuring peace and health for all by 2030 (WHO, 2015). As defined by the World Commission on Environment and Development, achieving sustainable development goals requires meeting our current needs without sacrificing the abilities of the next generations to meet their future needs (Thomsen, 2013).

SDGs contain a list of 17 goals and 169 targets, with the role of health for all populations centred in SDG 3: '*Ensure healthy lives and promote well-being for all at*

*all ages*' (p.3) (WHO, 2015), encompassing a range of issues, including tobacco control (Howden-Chapman et al., 2017). Tobacco control is closely related to the achievement of the UN SDG 3 since smoking is one of the leading causes of serious health issues worldwide (Howden-Chapman et al., 2017). Furthermore, tobacco use is also associated with other targets within SDG 3 (WHO, 2017b). For example, SDG3 Target 3.4 focuses on reducing premature mortality from non-communicable diseases, while tobacco use is a major risk factor for various non-communicable diseases (NCDs) (WHO, 2016). The associations between smoking and other diseases underline the significant impact of tobacco use on various health-related SDGs and the significance of effective and cost-effective tobacco control interventions, including mHealth interventions (Chapter 2, Section 2.6).

Tobacco use is a leading factor contributing to NCDs globally (WHO, 2016). Implementing measures to decrease tobacco consumption, such as smoking cessation interventions, remains one of the most useful strategies to save lives and boost global public health (Altas, 2022). Smoking cessation begins to benefit smokers from the first twenty minutes after the last cigarette, and the longer smokers keep abstinent from smoking, the more their health status recovers to the level of non-smokers (WHO, 2020c). Therefore, smoking cessation is necessary to help people prevent smoking- and non-smoking-related diseases and live in good health, as well as enhance their quality of life.

### 1.2.3 Economic burden of smoking on society

Around 80% of adult smokers live in low- and middle-income countries (LMICs) (WHO, 2023a). Smoking leads to diseases that necessitate healthcare expenditure, thereby deepening health inequities between high-income countries and LMICs and intensifying poverty in impoverished areas where health costs are unaffordable (Yang et al., 2022). Aside from SDG 3, smoking is linked with other SDGs, such as SDG 1, '*End poverty in all its forms everywhere.*' Smoking does not only cause various undesirable health outcomes but also imposes a tremendous economic burden on society (ASH, 2017). Apart from the direct medical expenses incurred in treating tobacco-related illnesses, there are other indirect costs, including productivity loss because of premature death and environmental harm (Altas, 2022).

The overall economic loss resulting from tobacco use outweighs any potential financial gains derived from tobacco production and sale (ASH, 2017).

Although the smoking prevalence level is dropping globally, the worldwide total amount of smokers continues to increase because of population growth (NCI and WHO, 2016), which means tobacco expenditure is still tremendous. For example, the Office for National Statistics approximated that the total expenditure of United Kingdom (UK) households on tobacco in 2015 amounted to £19.3 billion (NHS, 2016). A recent systematic review on the disease burden attributable to smoking in China reported that diseases caused by smoking have imposed significant economic costs on China, both directly and indirectly (Shi et al., 2020).

Tobacco sales generate huge tax income for governments, but despite generating enormous government revenues from global tobacco sales, only a tiny fraction is allocated to tobacco control or other health promotion initiatives (NCI and WHO, 2016). WHO estimated that from 2013 to 2014, global tobacco taxes generated nearly 269 billion United States (US) dollars, yet only less than one billion US dollars were invested in tobacco control programmes and health-related initiatives (NCI and WHO, 2016). Due to the limited resources put into smoking cessation, innovative, cost-effective, and efficient smoking cessation interventions are required to assist smokers to stop smoking. Since 80% of adult smokers come from LMICs (WHO, 2023a), tobacco use also imposes a disproportionate burden on poor and rich households due to unequal access to healthcare services and the diversion of household income towards tobacco consumption (NCI and WHO, 2016). It deviates from the principles of 'Health for all' from WHO since the 1970s, which underscored the high standard quality of primary health care and health for all individuals (WHO, 2012).

#### 1.2.4 Mobile apps in health fields

Mobile health (mHealth) is a digital health branch that uses mobile technologies to support medical and public health issues (WHO, 2011). The rate of the population getting access to health information and services through mobile technologies, from short message service (SMS) to health apps, is increasing (WHO, 2017a). According

to the Spring 2018 Global Attitude Survey, it was estimated that five billion people own mobile devices and half own smartphones (Pew Research Center, 2019). In advanced economies, smartphone ownership is notably high, with countries like South Korea at 95%, the Netherlands at 87%, Sweden at 86%, etc. (Pew Research Center, 2019). The high ownership rate of smartphones has made mHealth one of the promising interventions for addressing health issues. Furthermore, mobile technology has been popular over the last two decades in many fields, such as education (Heflin et al., 2017), nursing (O'Connor and Andrews, 2018), and epidemiology (Drew et al., 2020). The use of mobile apps in smoking cessation is also common, with a large number of studies exploring its effectiveness and design considerations for designing a satisfactory app (McClure et al., 2016, Cobos-Campos et al., 2020, Guo et al., 2023, Whittaker et al., 2019).

#### 1.2.5 Research gap

Although the effectiveness of mHealth interventions in smoking cessation fields has been highlighted by previous research (Whittaker et al., 2016, Vilardaga et al., 2016, Cobos-Campos et al., 2020, Bendotti et al., 2022), there is still a research gap in understanding how these interventions work for smokers to change smoking behaviour, specifically how the interplay between contextual factors and mechanisms contributes to different intended and unintended outcomes. According to WHO, 80% of adult smokers come from LMICs. However, the majority of smoking cessation mHealth interventions research was conducted in high-income countries, where smokers in these countries only account for 21% of global adult smokers (WHO, 2023a, WHO, 2023c). Therefore, there is an urgent need to perform smoking cessation research in LMICs, such as China.

China, with over 300 million smokers, accounts for one-third of the total smokers number worldwide (WHO, 2023b). The Chinese government launched the '*Healthy China 2030 plan*' in 2016 with an ambitious plan to control tobacco and to decrease the adult smoking rate from 27.7% in 2015 to 20% in 2030 (Guo and Quan, 2020). According to the most updated China Adult Tobacco Survey Report in 2018, the smoking rate among Chinese smokers aged 15 and over was still 26.6% (WHO,

2018). This means the '*Healthy China 2030 plan*' faces huge challenges to achieve its goal.

As of 2022, the number of smartphone users in China has reached 1.04 billion, accounting for 73.7% of the total population (Statista, 2024). The widespread coverage of smartphones and excellent Internet coverage in China make smoking cessation apps a convenient, cost-effective, and promising tool for quitting smoking. A content analysis of the current smoking cessation apps in the Chinese market found that the adherence level to standard clinical practice guidelines of these apps was low and called for the design of new and evidence-based smoking cessation apps (Cheng et al., 2017). Following this, another study investigated Chinese healthcare providers' and smokers' views and expectations on the features of smoking cessation apps (Xu et al., 2019). However, the mechanisms by which smoking cessation apps work and the contexts in which they are effective remain unclear. Therefore, it is essential to conduct research to explore different contextual factors, such as cultural, social, and individual factors, that influence the success of smoking cessation apps, as well as explore how these factors activate different mechanisms that lead to various outcomes.

### 1.3 Research aim and research questions

The goal of this research project is to use realist evaluation to understand how smoking cessation apps help Chinese smokers stop smoking. An important aspect of this study is the development and refinement of programme theories specific to smoking cessation apps, which can serve as valuable references for app developers who are keen to design apps that align better with user needs. Moreover, policymakers and decision-makers interested in improving the health of their population can utilise these programme theories to formulate relevant policies and guidance that promote the safe and effective utilisation of health apps. Instead of exploring whether an intervention works or not, realist evaluation is a theory-driven approach that aims to explore how an intervention works by unravelling how the interplay between contexts and mechanisms leads to different outcomes (Pawson and Tilley, 1997b). Currently, to the best of my knowledge, no previous research

explores the contextual factors in which smoking cessation apps work and the underlying mechanisms through which these apps can be helpful.

**Aim:**

The overarching aim of this study is to examine what aspects of smoking cessation apps work for Chinese smokers, under what circumstances, and how. The following research questions are addressed:

Q1. Under what contexts are smoking cessation apps able to help Chinese smokers stop smoking?

Q2. What are the underlying mechanisms by which smoking cessation apps help Chinese smokers stop smoking?

Q3. What are the intended and unintended outcomes for Chinese smokers after using smoking cessation apps?

Q4. What are the practical implications of the programme theories in terms of smoking cessation app development and usage?

#### 1.4 The rationale for choosing realist evaluation

It is often challenging to identify “how” an intervention works, especially with complex interventions, which are designed to address multifaceted issues incorporating behavioural, social, psychological, physiological, and environmental elements in changing behaviours (Campbell et al., 2000). Smoking cessation apps typically have various components, such as social support, education, distraction, etc., which work together to facilitate users’ smoking behaviour change (Zhang et al., 2023).

Additionally, the effectiveness of smoking cessation apps varies across diverse contexts and among heterogeneous populations (Regmi et al., 2017). Smoking cessation apps can be unequivocally characterised as complex interventions necessitating comprehensive evaluation methodologies. Realist evaluation offers an evaluation methodology that accounts for the complexity of an intervention and the context in which it is implemented. Realist evaluation can elucidate the causal connections of how smoking cessation apps lead to particular outcomes by identifying “what works, for whom, in what circumstances” (Pawson and Tilley, 1997, p.161) and provide a more rigorous, comprehensive, and transparent evaluation of how smoking cessation apps work.

By conducting realist evaluation, researchers can unravel the underlying mechanisms and contextual factors that contribute to the different short-term or long-term outcomes by making the contexts, mechanisms, and outcomes explicit in programme theories (Pawson and Tilley, 1997b). The ontological and epistemological basis of realist evaluation will be elaborated in Chapter 3.

### 1.5 Research stages overview

This PhD project encompasses three stages. Stage one involves formulating initial programme theories (IPTs), followed by testing IPTs in the second stage. The third stage focuses on the refinement of IPTs. The specific methods of the processes involved in formulating, testing, and refining IPTs will be explained in Chapter 3.

Table 1.1 shows the structure of the thesis in the three main stages.

	<b>Sources</b>
<b>Stage 1:</b> Formulating IPTs (Chapters 4,5,6)	1- Qualitative systematic reviews (Chapter 4) 2- Systematic review of RCTs (Chapter 5) 3- Interviews with health workers (n=6) (Chapter 6)
<b>Stage 2:</b> IPTs testing (Chapter 7)	Realist interviews and analysis with smokers who have used smoking cessation apps (n=24)
<b>Stage 3:</b> PTs refinement (Chapter 8)	Interrogate findings of stage one and two to provide an explanation of how smoking cessation apps work

### 1.6 The structure of the thesis

To facilitate readers' understanding and improve their reading experience, I will introduce the chapter sequence of this thesis and provide a brief overview of each chapter's content.

This first chapter has introduced the overall background around smoking cessation, mHealth interventions usage in this field, how the research gap was identified, the

rationale for choosing realist evaluation as the methodology, and the research aim and questions. In Chapter 2, I will present the background for this project, including the smoking contexts in China, the addiction recovery process, human-computer interaction (HCI), and several formal theories that will facilitate the PTs refinement in the final stage. Chapter 3 discusses philosophical considerations for realist evaluation and the research design, including how data collection and analysis methods were chosen at each stage. The process of formulating IPTs, including two systematic reviews and the results of interviews with Chinese health workers, will be presented in Chapters 4, 5, and 6. Following this, I will present the data analysis results of interviews with Chinese smokers in Chapter 7 to test IPTs. Chapter 8 is about the refinement of programme theories through interrogating findings in stages one (Chapters 4,5,6) and two (Chapter 7). Chapter 9 is the discussion chapter, presenting the main knowledge contributions of this study, the strengths and limitations of this research, and the overall conclusion of this PhD study.

# CHAPTER TWO: Background

## 2.1 Introduction

In this chapter, I will first introduce the crucial background knowledge underpinning this study and its relevant concepts and theories. It covers Chinese tobacco culture, addiction, relapse prevention, formal theories underpinning health behaviour change, and important Human-Computer Interaction (HCI) concepts.

## 2.2 Barriers to stop smoking in China: social and cultural background

A comprehensive understanding of the overall tobacco control environment in the context of China encompasses various aspects, which include political factors (political will, approval of joining FCTC, urbanisation, etc.) (Lv et al., 2011), historical factors (the resistance against opium use, the promotion of domestically-produced cigarettes brands, and linking smoking to patriotism) (Barnett et al., 2022), economic factors (monopoly of tobacco industry in China and income inequality) (Guo and Quan, 2020), and cultural factors (patriarchy and gifting culture, etc.) (Chu et al., 2011, Mao, 2013). However, due to the time and space constraints of the PhD project, exploring political, historical, and economic factors deeply will exceed the scope of this research. This section will emphasise the influence of traditional Chinese culture (including tobacco culture) on Chinese smokers' smoking and smoking cessation behaviours. Through deeply delving into these cultural aspects, I hope to unearth cultural barriers to smoking cessation specific to Chinese smokers. Lastly, gaining a comprehensive understanding of the cultural background is beneficial in interpreting the programme theories developed in the context of China.

### 2.2.1 Inadequate knowledge of the risk of smoking

Most Chinese citizens are aware that smoking generally increases the morbidity of various diseases, although there is a lack of deep understanding of the hazards of smoking (Zheng et al., 2013, Xu et al., 2016). In a survey conducted among smokers and non-smokers in China, it was found that the knowledge level of the association between smoking and lung cancer was comparable to that of Western developed countries (Yang et al., 2010a). However, only 40% (n=5986) of the participants (adult

smokers and non-smokers) were aware of smoking being a risk factor for heart disease, and only 20% (n=5986) of participants acknowledged that smoking could lead to stroke (Yang et al., 2010a). There was a similar survey to investigate the level of awareness of the hazards of smoking and second-hand smoking among adult Chinese residents. Yang et al. (2010b) also found that 81.8% (n =13354) of the participants had the belief that smoking causes serious diseases, while only 27.2% and 38.7% were aware that smoking is associated with stroke and heart attack, respectively.

Overall, it appears that some Chinese smokers have a superficial knowledge base of the hazards of smoking. Considering the apparent lack of in-depth knowledge about the effects of tobacco use and a specific understanding of what diseases smoking can contribute to, smokers in China may be unwilling or lack the motivation to stop smoking.

## 2.2.2 Traditional smoking culture

### *2.2.2.1 Tobacco sharing and gifting culture*

The culture of offering cigarettes to others in China can be culturally traced back to Confucian philosophical thought, particularly the virtue of courtesy (Barnett et al., 2022). As a cultural practice in China, it is common to offer cigarettes to others as a gift or to show kindness (Wu et al., 2022). This phenomenon may be unique to China, and it is culturally grounded in the pursuit of courtesy, where sharing and gifting cigarettes are used to express respect and solidarity (Chu et al., 2011, Hu et al., 2012).

In the past decade, research has indicated that in major and urban cities, such as Beijing, the phenomenon of sharing and gifting cigarettes has become less popular (Hu et al., 2012). In most regions, it is still a common practice among smokers to offer cigarettes to each other as a means of developing and maintaining social relationships (Wang et al., 2014) or establishing business cooperation (Wank, 2000). However, in recent years, with growing health awareness and changing social norms, the culture of sharing and gifting cigarettes seems to be declining, especially among the younger generation (Barnett et al., 2022).

### *2.2.2.2 Social norms: patriarchy and collectivism*

Despite the rapid economic growth in China in recent years, Chinese society continues to be men-dominated in family and political leadership, where smoking is perceived as a symbol of masculinity (Kodriati et al., 2018). Men who smoke might be perceived as more masculine in traditional Chinese culture (Davey and Zhao, 2012, Mao et al., 2015). Therefore, Chinese males are more likely to engage in smoking behaviour regardless of the risks of smoking due to masculinity norms.

Traditionally defined social norms and gender roles may have prevented Chinese women from smoking, which means Chinese female smokers may face more social stigma than men. In addition, the traditional social norms significantly limit females' influence in persuading their partners to quit smoking within households (Mao, 2013, Mao et al., 2014). Although non-smoking women in China dislike their partners' smoking behaviours, they often sacrifice their personal beliefs to ensure family harmony (Mao et al., 2013).

In China, collectivism is a social culture that emphasises collective interests and group harmony (Steele and Lynch, 2013). It involves hospitality, tight social connections, and tobacco and alcohol sharing (Li et al., 2015). Collectivism's influence on tobacco use in China mainly manifests in the smoking behaviour among a group of smokers. Usually, when situated within a group of peers who smoke, the decision to smoking cessation may be seen as deviating from group norms, leading to a sense of isolation (Barnett et al., 2022).

### *2.2.2.3 Self-exempting beliefs (SEBs)*

Self-exempting beliefs (SEBs) refer to the beliefs held by individuals that support their ongoing behaviours even if they know they are harmful. In the context of smoking, they are a set of reasoning or self-justification that individuals employ to rationalise smoking, undervalue the severe health impacts of smoking, or ignore the harmful consequences it may lead to (Chapman et al., 1993, Oakes et al., 2004, Guillaumier et al., 2016).

Culture can serve as the cornerstone of SEBs. In specific social and cultural contexts in China, the most common SEB is that cigarettes facilitate social interactions (Rich and Xiao, 2012). Sharing or gifting cigarettes is a common social norm and a polite social behaviour accepted by Chinese smokers. Another form of SEB is that the harm of smoking can be neutralised through other means, such as opening windows for ventilation to avoid second-hand smoking or consuming tea and fruits to metabolise the toxins in cigarettes (Barnett et al., 2022). The traditional Chinese medicine theory of balancing 'Yin' and 'Yang' can serve as the basis for this belief (Wu and Zhu, 2003, Lu et al., 2004). 'Yin' and 'Yang' are two contrary concepts interconnected and inter-dependent in Chinese philosophy, in which traditional Chinese medicine is rooted (Lao et al., 2012). In traditional Chinese medicine, health is gained through keeping the balance between 'Yin' and 'Yang'. Smoking is seen as bringing in excess "Yang", so enhancing 'Yin' intake, such as drinking tea and acupuncture, can neutralise the detrimental effects of smoking (Huang, 2019).

The final SEB among Chinese smokers is the perception that smoking is merely one of the risk factors of many diseases and not a direct cause of illnesses, mainly arising from a lack of comprehensive and deep understanding of the hazards of smoking (Barnett et al., 2022). Due to this SEB, many Chinese smokers do not believe that the negative outcomes of smoking will happen to them unless they experience a smoking-induced disease or witness someone close to them getting a serious disease due to smoking (Yang et al., 2010a).

## 2.3 Addiction and Relapse

### 2.3.1 Addiction models

Before delving into the topic of smoking cessation, it is helpful to know different types of addiction models, which provide different but complementary views to identify all factors contributing to smoking cessation. Addiction is characterised by the recurrent inability to control the behaviour (powerlessness) and the continuity to conduct the behaviour regardless of bad consequences (unmanageability) (Goodman, 1990). It is a bio-psycho-social disease that integrates biological, psychological, and social factors (Marlatt and Gordon, 1985).

Addictive behaviour often develops over time and can happen in specific situations, such as stressful environments, where the person with an addiction resorts to a particular behaviour to achieve immediate gratification. Therefore, for a very long time, addiction was regarded as an inability or lack of willpower to control the problematic behaviour. This is referred to as the moral model of addiction (Marlatt and Gordon, 1985). This moral model of addiction leads to social stigma because it is believed that the person with that addictive behaviour lacks the self-control to resist temptation (Stuber et al., 2009, Triandafilidis et al., 2017).

Subsequent to the moral model, the disease model began to surface, indicating that addictive behaviours are linked with brain change and predisposing physiological factors (Hall et al., 2015, Volkow et al., 2016). Although this new model regards addiction as a disease that is affected by physiological factors, the central theme of treatment is still 'control'. The only way to cure the disease is to maintain total abstinence from harmful behaviours, which produces a dichotomy in the outcomes of behaviour change: exerting control or losing control (Marlatt and Gordon, 1985).

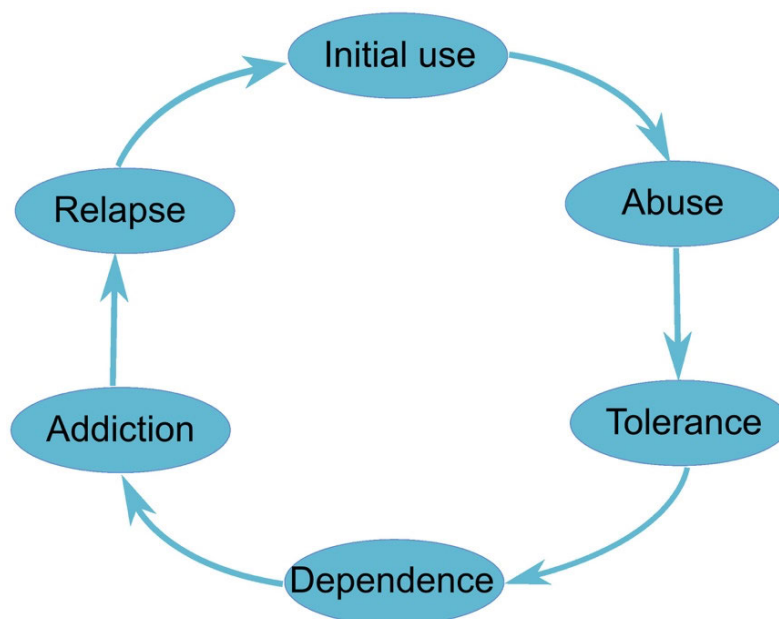
Given the shortcomings of both the moral model and the disease model, the third addiction model, acquired habit patterns, has emerged as an alternative. Within this model, disease is the long-term outcome of continuous involvement in the addiction cycle. The frequency of acquired habits lies along a continuum of harmful behaviour rather than discrete outcomes like excessive use or total abstinence (Marlatt and Gordon, 1985). This model allows for the possibility of relapsing during smoking cessation or gradually reducing the number of cigarettes rather than the total abstinence favoured by the previous two models.

I stand for the acquired habit model that recognises tobacco addiction as an acquired habit that incorporates biological, psychological, and social factors. In this model, addiction may involve changes in brain structure and chemical substances, leading to physiological dependence on substance use or harmful behaviour (Hall et al., 2015, Heilig et al., 2021). In addition, addiction could also be related to emotional and cognitive processes and other psychological aspects (Peris et al., 2020). Furthermore, addiction may be influenced by social factors such as social norms and cultural background (Chen, 2020). This habitual behaviour can play a significant role

in the addiction cycle, causing individuals to struggle with controlling their actions to break the addiction cycle.

### 2.3.2 Addiction cycle

Addictive substances, such as nicotine, have an impact on the brain (Heilig et al., 2021). They stimulate the pleasurable sensations when smokers initially consume tobacco (initial use). The feeling of pleasant sensation promotes smokers to overlook the potential harm to health and make the decision to consume tobacco continuously (abuse). With tobacco abuse, changes occur in the brain's structure and function, known as neuroadaptation (Office of the Surgeon General, 2020) (tolerance). Physiological dependence on nicotine occurs because the number of nicotine receptors in the brain increases and remains unchanged after initial smoking cessation (Balfour and Munafò, 2015) (dependence). Psychological dependence on nicotine arises from positive reinforcement, such as 'I like smoking', to negative reinforcement, such as 'I need to keep smoking to maintain this sense of pleasure' (Cosci et al., 2011, Office of the Surgeon General, 2020) (addiction). In other words, the brain changes that happen during tobacco use do not revert immediately when individuals quit smoking, which leads to persistent and periodic cravings for tobacco, resulting in relapse.



**Figure 2.1 Addiction cycle**

In the addiction cycle (Figure 2.1), relapse is a typical phase in the addiction cycle, which can be triggered by various factors, such as emotional problems. Rather than mean failure, each relapse can be regarded as an opportunity for learning and growth in the process of breaking the addiction cycle since it provides insights into triggers, helps refine coping strategies, and strengthens resilience (Melemis, 2015). Given that relapse is common in addictive behaviour change, I will further explain relapse prevention in Section 2.3.3.

### 2.3.3 Relapse prevention

Relapse in smoking cessation does not only mean the physical act of smoking again but also includes the emotional and psychological desire to relapse, leading to the eventual physical relapse (Marlatt and Gordon, 1985). Relapse has three stages: emotional relapse, mental relapse, and physical relapse (Melemis, 2010). Take smoking cessation as an example, in the emotional relapse stage, smokers do not consider smoking another cigarette, but they may experience emotional suppression due to the absence of nicotine. At this stage, self-care is essential (Melemis, 2015), such as ensuring adequate sleep, having a healthy diet, and understanding what is beneficial for themselves to help them get rid of negative emotions. Suppose smokers stay in the emotional relapse stage for a long time without venting emotions. In that case, they may enter the mental relapse stage, in which they start to miss the company of nicotine and may plan to have another cigarette. Recognising and avoiding high-risk situations that induce cravings and providing essential skills to overcome cravings are crucial at this stage. Physical relapse is the result of an extended stay in the mental relapse stage without enough coping strategies (Melemis, 2015).

Relapse recognition and prevention are crucial in successful smoking cessation since the temptation to smoke exists everywhere (Livingstone-Banks et al., 2019). Nicotine receptors in the brain need smokers to intake nicotine to achieve immediate gratification (Benowitz, 2010). In addition, when smoking has become an acquired habit, especially in situations where smoking was previously practiced, resisting cravings in these situations is challenging. Meanwhile, in the context of Chinese

smoking culture, Chinese smokers are constantly faced with 'temptation' from the people around them (Wu et al., 2022).

Throughout the whole process of changing smoking behaviour, self-control or self-management is important (Muraven, 2010). Situational cues can trigger the smoking behaviour of smokers who lack self-control or the capacity to resist or cope with cravings. Except for self-control, the outcome of a relapse crisis is also determined by smokers' coping responses to it, which are affected by other processes, such as decision-making (Marlatt and Gordon, 1985, Bliss et al., 1989). Therefore, no relapse prevention intervention can predict the success of smoking cessation since it is beyond a self-control problem. Different strategies are required to facilitate the advancement of smokers to persist abstinent for a longer time (Sun et al., 2007). Furthermore, smokers who are situated in different stages of smoking cessation, such as the preparation stage, action stage, and maintenance stage, may need other strategies to help them stay abstinent. I will explain this point in section 2.5.1: transtheoretical model (Prochaska, 2008).

Numerous studies have delved into the determinants of relapse among smokers, such as smoking cravings (Germovsek et al., 2021), negative emotions (Míguez and Pereira, 2021) and alcohol consumption (Dermody and Shiffman, 2020). Additionally, some high-risk situations have been identified for smoking relapse, such as situations with heightened arousal due to stress or anxiety in occupational settings and situations with reduced arousal when seeking relaxation at home or facing withdrawal symptoms (Marlatt and Gordon, 1985). Effective coping strategies for these high-risk relapse situations, such as deploying techniques like relaxation, meditation, physical exercise, and cognitive-behaviour therapy, are vital in preventing relapse (Lancaster et al., 2006, Wen et al., 2021).

## 2.4 How to break the addiction cycle

Addiction is a complex and multifaceted outcome shaped by the interplay of genetic, physiological, psychological, social, and cognitive factors (Glass, 1991). While discussing genetic factors and chemical changes in the brain goes beyond the scope of this study, I will introduce physiological (withdrawal symptoms), psychological,

social, and cognitive factors affecting smoking cessation in sequence in the following paragraphs to explain how to break the addiction cycle effectively.

After the abrupt cessation of chronic use of tobacco products, a set of withdrawal symptoms emerge within 4 to 24 hours of quitting, peak around the third day and gradually diminish over the following 3 to 4 weeks (Balfour and Munafò, 2015). Nicotine withdrawal symptoms include having cravings, feeling irritated, decreased concentration, insomnia, and weight gain (Hatsukami et al., 1984, CDC, 2022). Although the manifestation, intensity, and duration of withdrawal symptoms may vary between individuals (WHO, 2009), effectively managing these symptoms is crucial in breaking the addiction cycle.

Individuals with mental health problems and negative emotions, such as anxiety, depression, post-traumatic stress disorder, etc., are more prone to developing addiction (Xu et al., 2020). At the same time, positive reinforcement (the pleasure derived from smoking) and negative reinforcement (fear of negative emotions after leaving tobacco) also impede smoking cessation (Glass, 1991, West and Brown, 2013). Paying attention to psychological changes during the smoking cessation process and promptly identifying and releasing negative emotions are crucial in changing smoking behaviour.

As discussed in section 2.3.1, I stand for the acquired habit addiction model, which involves social components in the addiction process. Individuals acquire addictive habits by observing and imitating others, and the behaviours are reinforced through positive experiences, such as social convenience brought by smoking or social approval (Bandura, 1977). Take smoking cessation for example, it is difficult for smokers to quit smoking when people around them also smoke and show approval of the smoking behaviour (Mao et al., 2014). On the contrary, if smokers stay in a social environment that aims to quit smoking and advocates for a smoke-free lifestyle, it can better help them to quit because smokers tend to learn and imitate other quitters' behaviours (Qian et al., 2021). In addition, social factors, such as social norms, will also affect the decision-making process. For example, as introduced in section 2.2.2.2, traditional Chinese social norms prevent Chinese women from smoking and lead to more social stigma on female smokers. This

implies that social components are important in smoking cessation interventions to create an environment.

Cognitive factors, such as knowledge and belief in the risks of smoking and the benefits of smoking cessation, will also affect smokers' decision-making to stop smoking, especially when cravings strike (Rogers, 1975). Therefore, to help smokers break the addiction cycle, enhancing the beliefs that smoking is harmful to health and that smoking cessation is beneficial will promote the smoking cessation process. Self-efficacy is another important cognitive mediating factor that predicts the maintenance of the target behaviour, such as smoking cessation (Rogers, 1975). Self-efficacy refers to a person's confidence in their ability to successfully complete a specific task (smoking cessation in this context) (Bandura and Adams, 1977). By enhancing smokers' confidence in controlling cravings, setting achievable goals, and providing positive feedback, smokers will be more confident in quitting smoking and, therefore, more likely to keep abstinence to break the addiction cycle (Bandura and Adams, 1977, Bandura and Wessels, 1994). I will explain these points in section 2.5.2.

Overall, recognising that smoking behaviour is acquired and affected by the collective effects of physiological, psychological, social, and cognitive factors, smokers are regarded as 'victims' rather than being blamed. Just like correcting other bad habits, smoking cessation interventions which aim to help smokers recover from smoking addiction can involve withdrawal symptoms management, increasing psychological incentives, and providing social components and cognitive support, such as boosting self-efficacy (Hernández-López et al., 2009).

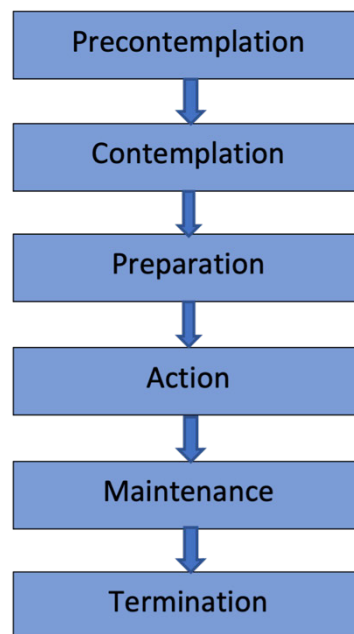
## 2.5 Formal Behaviour Change Theories

To fully understand the important factors that influence the process of breaking the addiction cycle, three theories were selected to provide different but complementary perspectives. These formal theories will also be helpful to understand and interpret the findings of this study (Chapter 8). In the smoking cessation context, the Transtheoretical Model examines the different stages smokers go through during smoking cessation (Prochaska and DiClemente, 1982). Protection Motivation Theory

explores how smokers are motivated to take protective behaviour based on their assessment of the severity and vulnerability associated with risky behaviour alongside the efficacy of protective behaviour (Rogers, 1975). Lastly, the self-determination Theory focuses on balancing intrinsic and extrinsic motivation and how these motivations influence smokers' decision-making processes (Deci and Ryan, 2013).

### 2.5.1 Transtheoretical Model

The transtheoretical model, also known as the stages of change model, incorporates tenets and processes of change from other leading theories of psychotherapy and behavioural change (Prochaska and Norcross, 2018). The stages of change in the Transtheoretical Model were initially found in studies of smokers trying to escape from addiction (Prochaska and Diclemente, 1983). Instead of viewing smoking cessation as a discrete event, smoking or no smoking, the Transtheoretical Model defines behaviour change, such as smoking cessation, as a process that involves six stages (Figure 2.2) (Prochaska, 2008).



**Figure 2.2: Stages of change in the Transtheoretical Model (Prochaska, 2008)**

Precontemplation is the first stage in which people lack awareness or underestimate the bad consequences of risky behaviour. Alternatively, they are discouraged from

altering risky behaviour because of too many prior attempts and failures, and as a result, they do not intend to change in the foreseeable future (Velicer et al., 1998). Smokers at this stage are characterised as resistant and unmotivated to stop smoking and may have low adherence to smoking cessation interventions (Prochaska, 2008).

Contemplation is the second stage in which people intend to change risky behaviour within the next six months but are often ambivalent about whether to change at once (Velicer et al., 1998). Smokers at this stage may start to think about smoking cessation but have yet to have a concrete plan. For smokers in the precontemplation stage and contemplation stages, boosting motivation for smoking cessation is essential (Prochaska and DiClemente, 1982).

The preparation stage is the third stage in which individuals are motivated to change immediately and often have a clear action plan (Velicer et al., 1998). Prochaska (2008) advocates that those individuals at this stage should be the target population for recruitment for intervention or treatment.

Action stage is the fourth stage in which people have significantly improved within the past six months (Velicer et al., 1998). In smoking cessation, 'Action' represents the process of behaviour change because addictive behaviour, including smoking, carries a risk of relapse, particularly during the early phases of behaviour modification when the addiction has not yet been completely overcome (Marlatt and Gordon, 1985). At this stage, relapse prevention is of great significance.

Maintenance is when people are less likely to relapse and become more confident about achieving behaviour change (Velicer et al., 1998). Depending on the extent of temptation and self-efficacy level, the maintenance stage can last from six months to five years until zero temptation and 100% self-efficacy are achieved, which is characterised in the termination stage (Prochaska, 2008).

According to the Transtheoretical Model, stages of change are unstable and can change at any time, mainly depending on individuals' decision-making process (Prochaska and Norcross, 2018). Therefore, in the context of smoking cessation, it is

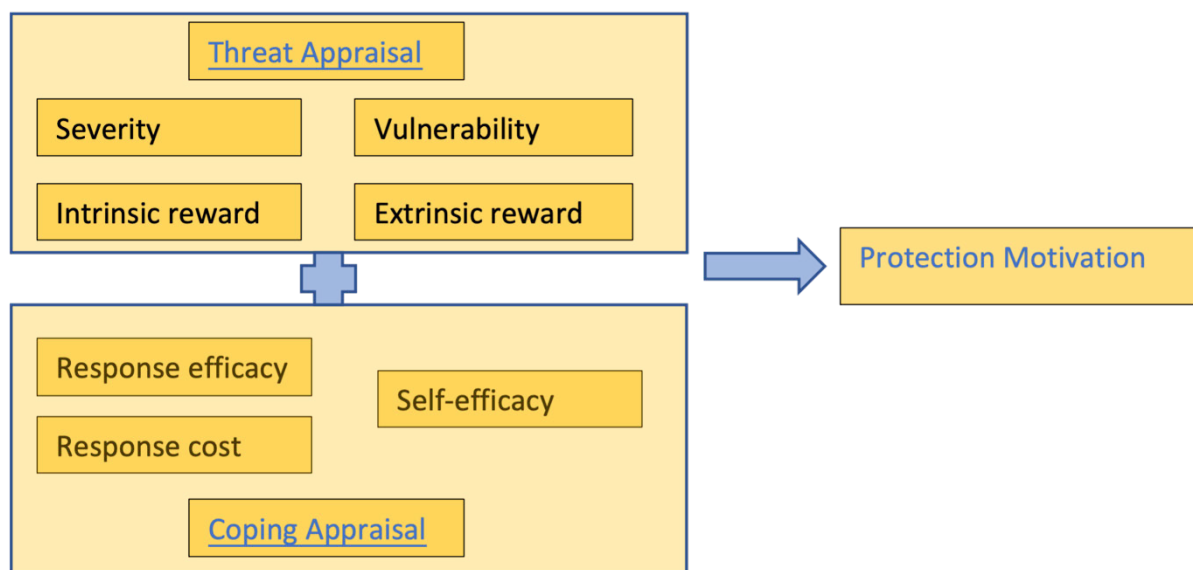
essential to enhance the beliefs that smoking is harmful and smoking cessation is beneficial (Prochaska, 2008). Besides supporting the decision-making process, Prochaska (2008) also proposed that providing positive reinforcement to individuals when they successfully resist cravings, providing social support so they can seek help, and reflecting on successful individuals in changing behaviours are helpful in achieving long-term behaviour change.

### 2.5.2 Protection Motivation Theory

Protection Motivation Theory is a psychological framework first established in 1975 (Rogers, 1975). It was then revised in 1983 to predict how people perceive and respond to threats, emphasising the importance of cognitive processes in behaviour change (Maddux and Rogers, 1983).

Revised Protection Motivation Theory proposed two cognitive processes mediating behaviour change: threat appraisal and coping appraisal (Maddux and Rogers, 1983). The threat appraisal is composed of intrinsic rewards, extrinsic rewards, vulnerability, and severity (Prentice-Dunn and Rogers, 1986), which evaluates factors that influence the possibility of the uptake of risky behaviours, such as smoking, while coping appraisal makes the judgements of the efficacy of preventive response (response efficacy), such as smoking cessation, the costs of taking preventive response, and self-efficacy (Prentice-Dunn and Rogers, 1986). The dynamic balance between the two pathways determines the possibility of taking the risky behaviour (Maddux and Rogers, 1983). Figure 2.3 shows the components of the Protection Motivation Theory.

Take smoking as an example, smokers take into account the pleasurable sensation and happiness they experience from smoking (intrinsic rewards), as well as the convenience it provides in social situations (potential extrinsic rewards). They also consider the possibility of developing diseases because of smoking (vulnerability) and what bad outcomes will be to their lives (severity). Simultaneously, people also evaluate their ability to decline a cigarette offered by others (self-efficacy), the advantages of quitting smoking (response efficacy), and the barriers they might encounter during smoking cessation (response cost).



**Figure 2.3: Protection Motivation Theory (Maddux and Rogers, 1983)**

According to Protection Motivation Theory, smoking cessation interventions should enhance awareness of the severe risks of smoking and individual vulnerability while also strengthening awareness of the benefits of quitting to provide ongoing support and motivation to stop smoking. Finally, the interventions should also include strategies to enhance smokers' self-efficacy in quitting smoking. Protection Motivation Theory provides valuable insight into how smokers decide to stop smoking through the balance of two cognitive pathways.

### 2.5.3 Self-determination theory

Self-determination theory was initially developed in the 1980s (Deci, 1985). It focuses on individuals' innate psychological needs and discusses how individuals make decisions and take actions based on these psychological needs. Three fundamental psychological needs which drive individuals to change risky behaviour are involved in SDT: autonomy, competence, and relatedness (Deci and Ryan, 2012b). Autonomy refers to individuals' need to feel they have control over their actions. Competence refers to the individual's feeling that they can succeed in behaviour change. Relatedness refers to the desire to be connected to others.

Take smoking cessation as an example, smokers need to feel that the decision to quit smoking is based on their own will rather than being forced by external pressures. This autonomy is a critical factor in stimulating the intrinsic motivation to quit smoking, allowing them to be more actively engaged in quitting (Williams et al., 2009). Competence refers to the extent to which smokers feel they are capable of effectively controlling their addiction (Williams et al., 2009). Lastly, relatedness means that smokers need to think that they are in a supportive environment where they can receive support from others and provide support to others (Williams et al., 2011).

Self-determination theory posits that fulfilling the psychological needs for autonomy, competence, and relatedness is the key driving force in changing smoking behaviour and achieving long-term abstinence. The current study provides a valuable framework for analysing participants' psychological needs in smoking cessation, thereby gaining a more comprehensive understanding of their decision-making processes and behaviour patterns. In the following sections, I will introduce the advantages and challenges of health apps and important concepts in HCI and discuss the application of mobile technology in smoking cessation.

## 2.6 Roles of mHealth in Smoking Cessation

### 2.6.1 Advantages of Health Apps

Providing interventions through mobile phones can offer various benefits (Davies and Mueller, 2020). The first advantage is the ubiquity of mobile phones. In developed countries, smartphones are ubiquitous among those under the age of 35. Although the ownership rate of smartphones varies significantly among different age groups and countries (Pew Research Center, 2019), the potential of health apps to manage disease or change behaviours is still considerable (Bousquet et al., 2017, Santo and Redfern, 2019, Alshagrawi and Abidi, 2023). In China, the rate of smartphone ownership stands at 74.5% up to 2023, with a forecast of an increase to 82.8% by 2027 (Statista, 2023).

Given the high penetration rate of mobile phones, health apps have the enormous potential to provide suitable support with the right type and specific intensity at the

right time based on individuals' circumstances and needs (Naughton, 2017, Nahum-Shani et al., 2018). Taking smoking behaviour as an example, smokers' cravings can strike at anytime and anywhere, so traditional smoking cessation interventions, such as face-to-face counselling, are limited by time and location. For example, scheduling appointments in advance or attending the appointment in person may be needed. Smoking cessation apps emerge as a promising tool to provide just-in-time support.

For individuals who are uncomfortable with face-to-face treatment for various reasons, such as fear of stigma, health apps may provide health information and support through a platform that enhances anonymity (Kim et al., 2022). Anonymity refers to the ability of health apps to protect users' identities, such as names and addresses, so users will not be identified while using the app (Wright, 2004).

In addition, health apps can enhance user experience through interactive features, including users' interactions within the app or communication with the chatbot (an automated programme designed to simulate interactive conversation with humans) (Zhang et al., 2023). For example, a common feature in smoking cessation apps is the social support function, which allows users to communicate with other users about their smoking cessation experiences and share their journey or achievements (Bendotti et al., 2022).

Compared with traditional interventions providing only static information, such as leaflets, health apps can be tailored to various user demographic traits and preferences (Davies and Mueller, 2020). The enhanced personalisation trait of health apps increases the likelihood of meeting users' needs (Ho and Bodoff, 2014). For example, smoking cessation apps could enhance personalisation by offering an assessment before use and providing tailored suggestions based on the assessment results (Regmi et al., 2017).

Lastly, traditional face-to-face interventions may require more resource inputs, such as transportation and staff training (Davies and Mueller, 2020). As a cost-effective approach to providing health support, health apps can maximise the utilisation of limited resources to support users without incurring additional costs for repeated use.

## 2.6.2 Challenges of Health Apps

Despite the advantages of health apps, they also face some challenges. The first one is the unequal access to the Internet and smartphones among different age groups and regions alongside the digital divide within some countries (Makri, 2019). Furthermore, the ownership rate of smartphones varies significantly among different age groups. For example, in 2018, 95% of the American young population (aged under 35) owned a smartphone, while this rate dropped to 67% among the population aged 50 and over (Pew Research Center, 2019). The age gap in smartphone ownership rate is more pronounced in developing countries. For instance, in the Philippines, the smartphone ownership rate among young people in 2018 was 74%, nearly three times the rate among people aged 50 and above (27%) (Pew Research Center, 2019). Additionally, due to the inevitable digital divide in regions with different levels of economic development, there is still debate on whether internet-based interventions can reduce the inequities in accessing resources, including health resources. For example, one study explored how disparities in access to digital tools and internet connection stability affect online learning outcomes among student groups. This study found that students who were in economically developed areas typically had better equipment and Internet connection. Therefore, they often made better use of the provided online educational resources (Guo and Wan, 2022).

The second challenge is the need for more high-quality apps. Despite some initiatives providing users with evidence-based, authoritative health apps (NHS, 2023), many apps on the market are not high-quality (Thornton et al., 2017). Thornton et al. (2017) identified 112 smoking cessation apps and evaluated their quality using the Mobile Apps Rating Scale. They found only six high-quality apps among all identified apps, and only two had been assessed for efficacy.

Compared with traditional face-to-face interventions or programmes which require cost investments (counselling administration fee, transportation, time cost, etc.), health apps are often free to download and require no formal commitment (Davies and Mueller, 2020). Research has shown that a high drop-out rate exists among

health app users, and addressing this could increase the effectiveness of health apps in managing diseases (Torous et al., 2020, Meyerowitz-Katz et al., 2020).

There are also issues of user privacy and security challenges. User privacy and security are essential considerations for app developers and also one of the risks users face when using mobile apps (Davies and Mueller, 2020). There has been research investigating this issue to raise public awareness (Adhikari et al., 2014, Al-Sharo, 2019). For example, Adhikari et al. (2014) investigated the most popular health apps (n=20) to identify user privacy and security issues. The results showed that 65% (n=13) of the apps required users to input personal information (such as name, address, date of birth, email address, etc.), while only 5% (n=1) of the apps mentioned that users could delete their personal information permanently. Additionally, 50% (n=10) of the investigated apps stored user data in the cloud, increasing the risk of user privacy breaches. Only 20% (n=4) of the apps provided data privacy and security information.

Finally, technical problems could be a challenge. Most health apps depend on a network connection (although some apps may allow certain offline features to be used). In addition, device conditions and technical problems, such as app lagging, freezing, data loss, etc., may compromise function or threaten user security, significantly impacting user experience and engagement (Auton et al., 2023).

### 2.6.3 Usability and User Experience of mHealth Apps

#### *2.6.3.1 Usability*

Emerging in the 1980s (MacKenzie, 2013), Human-Computer Interaction is a broad concept and a diverse discipline that draws upon the specialised knowledge of different domains, including psychology (Card, 2018), anthropology (Ritter et al., 2014), cognitive science (Cross and Ramsey, 2021), computer science (Carroll, 2003), linguistics (Cowie et al., 2001), etc. HCI focuses on how people use or interact with devices and systems that incorporate computation and how to make these devices and systems more usable and useful (Carroll, 2003).

Usability is an important domain within HCI. A usable system helps users achieve intended goals with effectiveness (whether users can achieve their intended goals successfully), efficiency (how fast users can achieve their goals), and user satisfaction (whether users like using the product), considering the specific context of use (Wu et al., 2017, Lee et al., 2019).

However, usability is not just about how easily and effectively the product can help users achieve outcomes. While usability has diverse definitions and facets (Shultz and Hand, 2015), most definitions encompass domains including learnability, memorability, productivity, and user satisfaction (Jordan, 2020). Learnability refers to how easily users learn how to use the product (Shultz and Hand, 2015).

Memorability, on the other hand, indicates how well users can recall how to use the product after a period of disengagement with the product (Frith, 2019). Productivity is composed of effectiveness and efficiency, focusing on how effectively and quickly users can achieve their goals after using the product (Frith, 2019). In Human-Computer Interaction, effectiveness refers to whether users can achieve their intended outcomes, such as smoking cessation, after completing tasks in products, such as smoking cessation apps (Everett et al., 2006). If users can achieve the desired outcome through interaction with the product, the product is considered effective. On the other hand, efficiency is about how much resources and time are needed to use the product to achieve tasks (Frøkjær et al., 2000). A product with efficiency enables users to complete tasks easily and intuitively. User satisfaction refers to the extent to which users are satisfied with the product meeting their needs and expectations physically, emotionally, and cognitively (Georgsson and Staggers, 2016). User satisfaction is a subjective domain, which means how pleasing it is to use the product and how acceptable it is for users to use it to achieve intended goals. It means a product may be usable to some users, but it does not necessarily mean it is usable to other users (Jordan, 2020).

Additionally, to enhance the overall usability of a product, during the user-centred design process, it should be considered how to meet the needs and requirements of as many users as possible, which is known as accessibility (Stephanidis et al., 1998). Accessibility refers to the extent to which a product can be used to achieve intended outcomes under specific contexts or by different populations with specific

needs and capabilities (ISO, 2013). In the field of smoking cessation, mobile apps can be customised to cater to the needs of various user groups, such as pregnant women or smokers with mental health issues, to enhance their usability and effectiveness (Wu et al., 2017, Gowarty et al., 2020).

With the increasing prevalence of mobile healthcare technology (Kumar et al., 2013), usability has become more crucial. Although specific system attributes can make the product more usable, usability is the outcome of the interaction between the product (e.g. smoking cessation apps) and its users (individuals who interact with the product, such as smokers who use apps to quit smoking) (ISO, 2018).

### 2.6.3.2 User Experience (UX)

In the past decades, studies have moved the focus beyond usability to more engaging design with positive UX (Hassenzahl and Tractinsky, 2006, O'Brien and Cairns, 2016). UX is an umbrella term that covers how users perceive and react to a product, including users' beliefs, preferences, perceptions, behaviours, etc., that occur before, during, and after interaction with the product (ISO, 2010). Anyone with little expertise in coding and UX design principles can develop apps. However, these apps may be flawed and of low quality (Wright et al., 2018). UX design is the overarching principle for all app design, given that a usable product with bad UX that fails to capture users' attention will lose user engagement (O'Brien and Toms, 2008).

Peter Morville designed a 'honeycomb' model of UX, which incorporates seven facets, each representing the perceptions users have when they interact with the product: useful, usable, desirable, findable, accessible, credible, and valuable (Morville and Sullenger, 2010). Table 2.1 shows the meanings of the seven attributes.

<b>Domains in UX</b>	<b>Definition</b>	<b>Smoking cessation apps as an example</b>
Useful	The product is useful in assisting users to achieve intended outcomes	Users find the app useful to help them stop smoking

Usable	The product can help users achieve intended goals with effectiveness, efficiency, and user satisfaction	Users can efficiently use the app to support their goal of smoking cessation, and they like using the app
Desirable	Be able to evoke users' emotions	Apps employ emotional elements to stimulate users' emotions and motivate them to quit smoking
Findable	Easy to locate the functions that users need	A navigable design that users can find what they need easily
Accessible	Accessible to people with different capabilities	Users with special needs, such as people with poor vision or limited dexterity, can access the app
Credible	Users trust the product	Users trust and believe what the app tells them
Valuable	The product can benefit users and sponsors	Users value the support provided by the app in reaching their goal of smoking cessation

Table 2.1 User Experience Domains

The success of health apps largely depends on UX (Partala and Saari, 2015). If users have a positive UX when using apps, it can boost their motivation, making them more inclined to persist in using the app during the behaviour change process (Vilardaga et al., 2016, Spillers and Asimakopoulos). Conversely, negative UX may cause users to lose interest in the app, reducing the possibility of achieving the intended outcomes (Akter et al., 2013, Kim et al., 2019).

#### 2.6.4 Smoking cessation apps as an intervention

Smoking cessation apps are designed to provide users with a supportive and user-friendly environment to help smokers quit smoking. Apps with good usability can ensure users can access app functions and resources easily without encountering complex interfaces or operations (Wu et al., 2017, Gowarty et al., 2021). Moreover, smoking cessation apps can help smokers stop smoking by offering social support, virtual rewards, positive feedback, consideration of privacy issues, and personalised

support to boost motivation to stop smoking and increase user engagement (Zhang et al., 2023).

Different types of smoking cessation apps have existed on the market, including calculator type, calendar type, rationing type, hypnosis type, and gamified type (Abroms et al., 2011). 'calculator type' generally tracks how much money saved and how many health benefits gained because of quitting smoking; 'calendar type' track how many days have passed since the quit date; 'rationing type' control or limit the amount of tobacco use thereby helps users gradually quit smoking; 'hypnosis type' aims to change the smokers' mindset and reduce the smoking cravings; 'gamified type' employs game-like elements within apps to make the smoking cessation journey more motivating and enjoyable (Abroms et al., 2011, Edwards et al., 2018, Rajani et al., 2021a). There are also some smoking cessation apps designed to identify smoking patterns and triggers to cravings to help smokers better avoid high-risk situations, alongside offering educational content on the risks of smoking and the benefits of smoking cessation (Zhang et al., 2023). Most smoking cessation apps employ a mix of different features to help smokers achieve their intended outcomes effectively (Rajani et al., 2021a).

Smith et al. (2017) found that user engagement with apps can be productive and counter-productive, while user disengagement can be productive and non-productive. For example, when smokers feel overwhelmed by the contents of the app, counterproductive engagement can happen. Interestingly, the study also found that disengagement can be productive. For instance, some users believed that once they felt in their ability to stop smoking, they would stop using the smoking cessation app but still focus more on quitting smoking. Unravelling the underlying mechanisms by which smoking cessation apps work would enable app developers to optimise the effective mechanisms that aid smokers in quitting while minimising any counter-effective mechanisms that impede the smoking cessation process. However, no existing research has identified the mechanisms through which smoking cessation apps help smokers change smoking behaviour. Engagement with these apps could be counterproductive without a clear understanding of these mechanisms. Therefore, this study is of significance in understanding these underlying mechanisms.

## CHAPTER THREE: Methodology and research design

### 3.1 Introduction

Human beings are inherently endowed with the ability for philosophical thinking (Matthews, 1994). Clarity regarding the decisions that influence research outcomes is crucial for the meaningful interpretation of the research, making a solid understanding of philosophy essential (Hollis, 1994). Using realist evaluation methodology, the overall aim of this project was to examine what aspects of smoking cessation apps work for Chinese smokers, under what circumstances, and why.

This chapter presents the philosophical paradigms underpinning the research and the methodology and methods employed in this study. I will first introduce the ontological and epistemological position of realism, which underpins realist evaluation. Then I will introduce different strands of realism, including scientific and critical realism. Following that, I will elucidate different theoretical perspectives and the philosophical foundation of realist evaluation, followed by what 'theory' means in realist evaluation. Next, I will explain why programme theory is essential in realist evaluation. The methods of formulating, testing, and refining programme theories and how they were applied in this study to guide the research are explained. Finally, I will present the ethical considerations in this study and the methods at each research stage.

### 3.2 Philosophical underpinnings

Philosophy includes the objective natural laws that govern the entirety of existence, establishing an immutable and irrefutable framework that underlies all aspects of reality (Hollis, 1994). It equips us with overarching principles for theoretical thinking, a cognitive approach, a unique perspective, and self-awareness (Deleuze and Guattari, 1994). These invaluable assets enable people, with or without a social science background, to acquire a deeper understanding of reality and facilitate the design, implementation, analysis, and interpretation of social science research and its outcomes (Heberlein, 1988, Winch, 1990, Mascia et al., 2003, Newing, 2011, Moon and Blackman, 2014).

Having a thorough grasp of the fundamental principles and underlying assumptions of the specific field, such as nursing health, is essential for researchers and greatly beneficial when interpreting research findings distinct from other disciplines (Sievanen et al., 2012, Moon and Blackman, 2014). Therefore, it is important to examine and deconstruct the ontology and epistemology that underpins the current study.

### 3.2.1 Realism: where is it in ontology and epistemology?

In this study, I hold the view that realism sits closer to post-positivism in ontology and closer to constructivism in epistemology, which acknowledges the independently existing reality, and we can gain knowledge about the unobservable part of reality through capturing human perceptions and experience (Kozhevnikov et al., 2020).

Ontology focuses on the essence of existence, the nature of entities, and their relationships (Jacquette, 2002). It examines the fundamental characteristics of existence, the classification of entities, and their attributes (Jacquette, 2002). Every robust social science research is built upon ontological foundations, encompassing theoretical viewpoints regarding the nature of the research subject, even if these viewpoints are not explicitly articulated (Kozhevnikov et al., 2020). The research aim of this study was not to examine whether smoking cessation apps work but to explore how they work. Realism ontology aligns well with my research aim since realism posits the understanding of the unobservable and hidden causal relationships and mechanisms to explore reality (Kozhevnikov et al., 2020).

Positivism is grounded in the ontological assumption that an objective reality exists independently of human perceptions and subjective values (Adam, 2014b). In positivist epistemology, only those observable facts are regarded as sources of knowledge (Aliyu et al., 2014, Adam, 2014a), and it emphasises the use of scientific methods and empirical observation to understand and explain the world (Adam, 2014b). On the other hand, post-positivism emerged as a response to some limitations of positivism. Although it shares a similar ontological point that an independent reality exists, post-positivism acknowledges that what is observed and how it is interpreted can be influenced by human perceptions and experience (Groff,

2004). Post-positivism recognises that researchers may bring their assumptions, biases, and theoretical frameworks to their research and aims to be transparent about these influences, regardless of acknowledging the independent reality (Aliyu et al., 2014, Adam, 2014a).

Realism shares a similar ontological view with post-positivism, which recognises that an external reality exists independently of human perceptions and beliefs and that both the observable and unobservable reality exist (Collier, 1994, Bhaskar, 1975, Bhaskar, 2010). In the context of this study, underlying mechanisms by which smoking cessation apps work are often unobservable but exist independently of our perceptions. These mechanisms can be unravelled using a realist lens.

Epistemology, also known as the study of knowledge, concentrates on the essence of knowledge and the way we generate it (Hollis, 1994). Positivism epistemology advocates that knowledge should be based on observable and measurable facts, pursued through scientific experiments and observations to achieve an objective understanding, while post-positivism epistemology acknowledges the limitations of human cognition, emphasising the critical nature of knowledge (Adam, 2014b). Constructivist epistemology, on the other hand, posits that knowledge is constructed through the combination of social interactions and cultural contexts (Osborne, 1996). It suggests that humans actively construct knowledge and understanding based on their experiences, interactions, and mental processes (Osborne, 1996, Guba and Lincoln, 2005). Constructivism posits that our sense of reality and its existence is inherently uncertain, and it challenges the notion of absolute truth or falsehood (Kukla, 2013). Realism supports that knowledge is independent of human construction but can be acquired through capturing perceptions and experience, and the goal of gaining knowledge is to understand and interpret the independently existing reality (Collier, 1994).

Both positivism and post-positivism employ the successionist model, which emphasises the number of times we observe what happens. However, while both realism and post-positivism reject the positivist idea of a completely objective and value-free science, realism is distinct from post-positivism by emphasising uncovering objective realities and identifying generative causal mechanisms (Collier,

1994, Groff, 2004). In the context of this study to explore how smoking cessation apps help smokers quit smoking, I believe that there are hidden and latent mechanisms existing beneath the observable reality, such as experiences. I also believe these latent mechanisms can emerge by capturing human perceptions or experiences.

Table 3.1 presents my understanding of the differences between post-positivism, constructivism, and realism based on their understanding of the existence of independent reality, knowledge acquirement sources, and the goal of acquiring knowledge.

	Post-positivism	Constructivism	Realism
Independent reality	Yes, unlike positivism, it accepts that human values, experience can influence what is observed and how it is interpreted	No, reality is constructed or shaped by human cognition, perception, and interpretation.	Yes, there is an external reality that exists independently of our perceptions and beliefs
Knowledge acquirement sources	Can be identified and reported through observable facts but may be affected by human perceptions and experience	Constructed by human experiences, interactions, and mental processes	The unobservable knowledge can be acquired through capturing perceptions and experience
The goal of acquiring knowledge	To approach objective reality as close as possible	To establish understanding and interpretation of the world	To understand and interpret the independently existing reality
Causal reasoning	Successive causation	Prone to successive causation	Generative causation
Summary	Realism sits closer to post-positivism in ontology but differs in the causal reasoning approach. Realism sits closer to constructivism in epistemology		

Table 3.1 Differences between post-positivism, constructivism, realism (Groff, 2004, Kukla, 2013)

There are two primary forms of realism: scientific realism and critical realism (Mukumbang et al., 2023). Overall, scientific realism primarily focuses on describing and explaining scientific theories, emphasising the objectivity and truthfulness of science and aiming to provide approximations of truth (Boyd et al., 1984). On the other hand, critical realism allows researchers to deeply explore social phenomena, their causes, and their effects by considering the interplay between underlying structures and human agency (Collier, 1994, Kozhevnikov et al., 2020). I will explain the key tenets of scientific realism and critical realism in the following sections.

### 3.2.2 Scientific realism

Scientific realism extends beyond the realm of the observable world, which can be comprehended through anthropocentric methods and observational measurements to encompass the unobservable aspects of reality (Boyd et al., 1984). According to the scientific realism semantic notion, science aims to give a literally true account of the world (Mukumbang et al., 2023). It argues that scientific methods, which start by establishing a hypothesis based on observations and then test it through experiments (Castillo, 2013), are reliable. It also posits that the entities postulated by scientific theories, such as mechanisms, exist (Boyd et al., 1984, Chernoff, 2007).

The epistemic notion of scientific realism is called the 'no miracles' argument based on the inference to the best explanations, which means the best explanation among a set of candidate explanations is most likely to be true (Frost-Arnold, 2010). The 'no miracles' argument is aimed at convincing the success of scientific theories in explaining and predicting phenomena because they largely reflect the essence and structure of the real world (Frost-Arnold, 2010). Scientific realists not only accept that reality exists independently of human perception but also hold the view that they can capture the truth about the nature of reality through scientific theories (Chernoff, 2007). It can be suggested that scientific realists start from common sense and abductive thinking to formulate hypotheses and select those that offer the best explanation as the explanation of reality (Mukumbang et al., 2023).

From the semantic notion of scientific realism, any scientific pursuit should take the activity of retrodution to uncover why things exist as they are (Jagosh, 2020). Retrodution involves making inferences to formulate and assess underlying and unobservable mechanisms (Jagosh, 2020). An abductive thinking, which uses creative imagination, is needed in retrodution (Chiasson, 2005). Abduction is a unique type of logical inference, which has an epistemological aspect as it focuses on suggesting hypotheses that explain an observation (Chiasson, 2005), and retrodution refers to a comprehensive logical approach that integrates abduction, induction and deduction (Jagosh, 2020). Retrodution gains its prominence as it includes exploring the hidden causal relationships that underlie observed entities or changes happened to identify the unobservable patterns (The RAMESES II Project, 2017b).

### 3.2.3 Critical realism

Critical realism is distinct from scientific realism because it recognises that our understanding of reality is influenced by our social and historical contexts (Collier, 1994). Understanding the key tenets of critical realism is important to give the rationale for adopting it as my ontological position because it shapes my understanding of knowledge and how I acquired it in the current study. Specifically, understanding the key tenets of critical realism influenced the methods chosen for this study, including how I collected and interpreted findings. In the following sections, I will introduce the key tenets of critical realism.

#### 3.2.3.1 *Stratified reality*

Although scientific realism recognises the ontological depth of reality, which is composed of observable and unobservable entities, it does not clarify the layers of reality introduced by Bhaskar (1975). Critical realism, however, clarifies where these observable and unobservable entities exist (Mukumbang et al., 2023). Bhaskar (1975) introduced a three-tiered categorisation consisting of the 'Real, Actual, and Empirical' levels. Critical realism posits that the 'real' causes the 'actual', which may or may not be observed through the 'empirical' (Collier, 1994).

What can be observed in the domain of 'empirical' is driven by the objective entities, such as mechanisms, that exist independently of human perception. Progressing to the 'Actual' domain, it posits that the objective entities not only exist at the empirical level but also incorporate events that are either observed or not. While certain events can be scientifically observed or captured, others cannot be observed even using the best scientific observation tools because they occur beyond perceptual abilities or happen in specific contexts that are not easily captured (Brekke and Anastas, 2019). Nevertheless, irrespective of the observability of these events, they are considered situated within the 'Actual' domain, as they undeniably happened. Finally, the domain of 'Real' encompasses the entirety of the aforementioned observable or unobservable constituents, regardless of their observability (Figure 3.1). These observable and unobservable structures and mechanisms are recognised to exist in the realm of 'Real', and what realist researchers need to do is to unravel the hidden mechanisms and contextual conditions that are combined to determine whether an intervention or social programme will work or not through the realist lens.

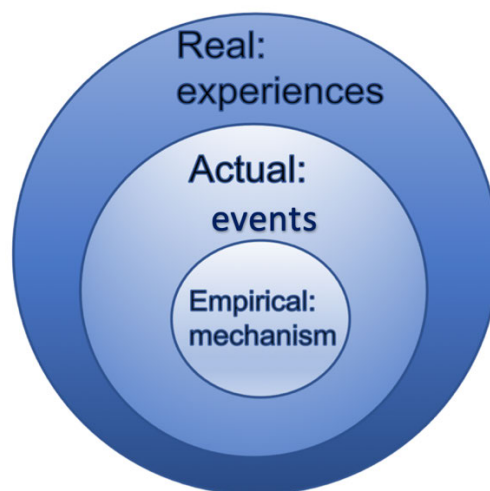


Figure 3.1 Three levels of reality (Adapted from Bhaskar (1975))

### 3.2.3.2 Embeddedness

According to Pawson and Tilley (1997b), embeddedness indicates that all human actions (social phenomenon) are embedded within a range of “*stratified nature of social reality*” (p.64). They explained this through the example that we accept cheques as a valid form of payment due to the recognition and acknowledgement of the social organisation known as the banking system and its role. Embeddedness,

referred to as social phenomena, is not isolated or independent entities but is deeply rooted within a larger social, economic, and historical context in diverse subjects (Granovetter, 1985, Dacin et al., 1999).

The central theme of critical realism that reflects embeddedness is emergence, advocating for a stratified or layered understanding of reality (Collier, 1994, Archer, 1995, Bhaskar, 1998). It implies that social phenomena have qualities and characteristics that cannot be fully explained by analysing them individually. For example, in this study, the understanding of smokers' smoking behaviour cannot be isolated from the specific Chinese smoking culture, such as regarding sharing cigarettes as a way to establish social relationships. The social function of smoking can be a barrier for Chinese smokers to stop smoking and requires the social support features within apps to provide social support.

### *3.2.3.3 Open systems*

To test the causal relationship that 'X leads to Y' in traditional experimental studies, a 'closed' system, in which the unique variable 'X' can be isolated from any other factors. For example, in a two-arm randomised controlled trial (RCT) to test whether a medicine is effective, the only variable between the control group and intervention group should be the existence of the medicine. However, in this study, it is unrealistic to have two separate groups in a 'closed' system, with a smoking cessation app as the only variable in the two groups.

An 'open system' suggests that the world is the result of the interplay and connection between diverse social entities embedded in multiple broader social contexts and external factors (Fleetwood, 2017, Pawson et al., 2005). Pawson and Tilley (1997b) concluded that failing to recognise social phenomena as an open system leads to an exclusive emphasis on the "input" and "output" aspects of causal relationships and ignorance of the crucial "throughput" (p.40), which refers to the processes that occur within a system as it interacts with various social entities over time. By overlooking the dynamic interplay and exchanges taking place within the open system, an incomplete understanding of social phenomena may arise (Collier, 1994). In an open system, the causal relationship between 'X' and 'Y' is not linear; instead, it is realised through multiple mechanisms and intermediate processes. For example, when

exploring how a smoking cessation app helps smokers quit smoking, smokers' decisions to quit smoking are influenced by various factors, such as their personal motivation to quit, social support level, etc. If the 'open system' is not recognised, it may lead to overlooking other influencing factors and focusing solely on the role of smoking cessation apps in the quitting process.

Human potential to alter society is infinite through the interplay between different social entities and generates both observable and unobservable patterns that manifest as events, known as demi-regularities, within the realm of the 'Actual' (Fletcher, 2017). These demi-regularities are not strict causal relationships or definite patterns but are trends that regularly happen under specific conditions. The concept of demi-regularities, rather than deterministic regularities, also emphasised that context plays a significant role in shaping outcomes. Individuals' interaction with different social entities can result in multiple mechanisms, allowing alternative or unintended outcomes to be observed (Danermark, 2001). For example, in the current study, demi-regularities, such as the relationships between user engagement level and the successful rate of smoking cessation, could potentially be identified. This demi-regularity may indicate that the relationship between high user engagement and high success rate is a trend, but this trend may depend on specific contexts, such as whether the app features meet users' needs.

Since this study is a realist evaluation, understanding the core principles of realism that underpin realist evaluation is crucial for promoting the uptake of realist evaluation research and enhancing the utilisation and implementation of research findings (Marchal et al., 2012, Mukumbang et al., 2023). After understanding the key tenets of realism, in the following sections, I will explain what realist evaluation is, how it is distinct from other evaluation types, and the rationale for choosing it in this study.

### 3.3 Realist evaluation: what is it and how is it distinct from other evaluation types?

Realist evaluation is a theory-driven approach to evaluating complex social interventions or programmes (Pawson and Tilley, 1997b). Instead of answering the

question, 'Does X lead to Y?', it explores the deep driving force that causes the changes. Realist evaluation is distinguished from other evaluations by its unique causation reasoning approach.

### 3.3.1 Scientific reasonings of causation

Two scientific reasonings about causation, successionist and generative causation, offer contrasting perspectives. Realists embrace generative causation while shunning the successionist view (Pawson and Tilley, 1997b). Both successionist and generative causation theories acknowledge the underlying assumption that a specific connection exists between two events, which can be explained through scientific methods. They recognise the importance of understanding causal relationships that exhibit regular patterns instead of attributing them to random or coincidental occurrences (Harré, 1985).

The successionist view of causation, however, is predicated on a series of discrete events and has some weaknesses. For example, researchers conduct many repeated experiments in RCTs to establish a causal relationship, concluding that 'X leads to Y'. As explained in section 3.2.3.3, X must be the sole variable in these experiments, while other influencing factors are rigorously controlled.

However, when evaluating social programmes, a range of challenges arises from this approach. Pawson and Tilley (1997b) used the example of the evaluation of the '*Cognitive Skills*' programme to elucidate it. To know whether this programme is effective in preventing conviction and readmission rates, a rigorous RCT was designed. During the research design process, the following problems were encountered by evaluators in this project: (1) The ethical issue of randomly assigning participants to an intervention group and a control group; (2) A potential bias may arise if people volunteered to participate in the intervention group; (3) The excessive emphasis on methodological rigour and precision in RCT design sometimes overshadowed the exploration of the underlying problem being addressed and the nature of the programme under evaluation; (4) During the implementation and participation in the programme, there were too many uncontrollable variables, such as participants' backgrounds and compliance. In this study, smoking behaviour could

be considered a complex problem because it is influenced by multiple social factors and, therefore, requires smoking cessation apps to make changes at various levels to achieve the desired changes. It is unrealistic to understand how smoking cessation apps work in a 'closed' system where all other interfering variables are controlled.

On the other hand, in generative causation, factors other than the primary variable are not perceived as interfering and extraneous variables requiring strict control but rather as contributors to the outcomes (Figure 3.2). Conversely, generative causation implies that human behaviours can only be understood within the context of specific social systems in which they trigger subsequent behaviours. This perspective recognises the complex interaction of causal factors and the emergent properties that arise from social systems. Realist evaluation aligns with generative causation because it acknowledges the causal dynamics inherent in complex social systems, rejecting the successionist perspective of causation that posits causation as a sequence of discrete events (Pawson and Tilley, 1997b). In the current study using realist evaluation to examine how smoking cessation apps help Chinese smokers stop smoking, generative causation plays a central role. This approach focuses on understanding the underlying mechanisms through which the app features activate specific changes in smokers. Exploring the contexts in which these mechanisms operate effectively can uncover why and how apps lead to successful smoking cessation for different smokers under varying conditions. This generative causation reasoning allows for a deeper understanding of the multifaceted interactions between smokers, apps, and the social contexts they situate.

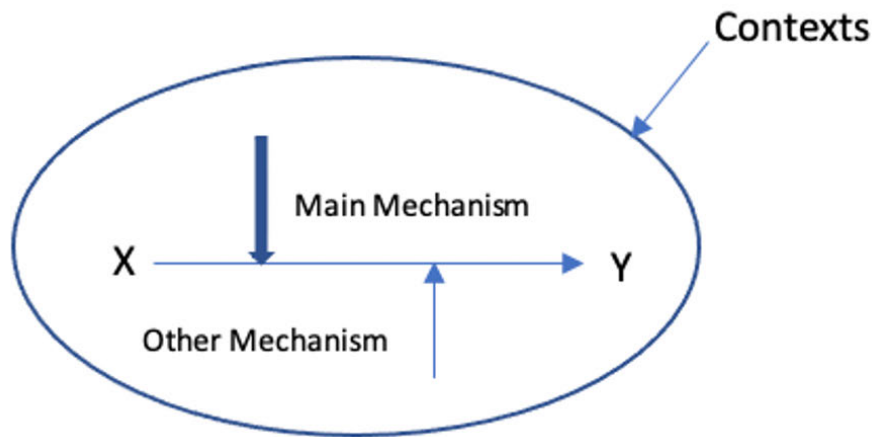


Figure 3.2 Generative Causation in realist evaluation (Adapted from Pawson and Tilley (1997b) )

### 3.3.2 Theory-driven evaluation: what does ‘theory’ mean?

Theory-based evaluations focus on understanding how an intervention leads to intended outcomes, which makes the hidden and latent mechanisms explicit. Otherwise, it will be difficult to interpret the success or failure or mixed results of the programme or intervention. In these approaches, the importance of theory is emphasised as it can explain why an intervention is effective or fails to achieve the expected or intended outcomes (Wight et al., 2016). The ‘theory’ in evaluation has four meanings: philosophical theory, evaluation theory, formal theory, and programme theory (The RAMESES II Project, 2017c).

Philosophical theories explain the causal relationships between things and how they occur. In section 3.2, I explained that the philosophical basis of realist evaluation is the realism philosophy of science.

Evaluation theory examines how various entities can be evaluated and what conclusions can be drawn regarding the outcomes to help define evaluation questions, select appropriate evaluation methods, collect and analyse data, interpret findings, and draw conclusions (Westhorp et al., 2011). Evaluation theory is about evaluation itself, such as methodology based on the epistemological assumptions, methods used for data collection and analysis, and roles of evaluators, etc. (The RAMESES II Project, 2017c). Realist evaluators adhere to the overarching

evaluation theory known as realist evaluation, elucidating the process by which programmes generate outcomes.

Formal theory, or substantive theory, is a set of theories that work in specific disciplines and provide a massive theoretical foundation of existing knowledge and evidence. However, relying solely on formal theories from past literature can sometimes be too abstract or disconnected from the specific programme or intervention, which makes it necessary to develop customised theories, called programme theories, that can then be supported by formal theories. In the following sections, I will explain the core constructs of programme theory.

### 3.3.3 Programme theory

Programme theory is a structured model that presents the underlying logic behind a programme or intervention, which aims to explain how a programme or intervention is expected to work (Funnell and Rogers, 2011). With a successful programme or intervention that has achieved intended outcomes, programme theory can help evaluators identify essential elements within the programme or intervention. If a programme or intervention fails to cause intended outcomes, programme theory also works to help evaluators know it is because the programme or intervention does not work or the implementation route is inappropriate (Wight et al., 2016). Lastly, if a programme or intervention causes mixed results, some participants achieve the intended outcomes while others fail. Programme theory helps evaluators to identify whether the programme or intervention only works in specific contexts or populations. Table 3.2 summarises the impact of programme theory on interpreting different evaluation results.

Programme implementation result	Programme without programme theory	Programme with programme theory
Successful	The logic model containing intermediate processes or outcomes is	<ul style="list-style-type: none"> <li>Identify essential functional elements so the programme can be adapted to other settings</li> <li>Identify intermediate outcomes</li> </ul>

Failed	absent, so it is hard to explain results	<ul style="list-style-type: none"> <li>Identify whether it is the programme itself or the implementation route that leads to the failure</li> </ul>
Mixed results		<ul style="list-style-type: none"> <li>Identify whether the programme only work in specific contexts or among specific population</li> </ul>

Table 3.2 Functions of Programme Theory (Funnell and Rogers, 2011, Wight et al., 2016)

Programme fidelity, which measures to what extent an intervention is delivered adhering to the programme protocol originally designed (Mowbray et al., 2003), is trying to be achieved through controlling variables in experimental designs, such as RCTs. Fidelity is not failed, but rather re-articulated in the form of programme theory in realist evaluation (The RAMESES II Project, 2017a). Sitting in ‘open systems’, where all people, information, and resources are dynamically communicated with each other, realist evaluation makes the assumption that the programme outcomes could be different in different people even though the identical programme is delivered since the effectiveness of the programme is determined by different contextual factors, social factors, human volition etc. (Pawson and Tilley, 1997b). The aim of realist evaluators is to understand and articulate that, compared with programme theory, what adaptations have happened and why they occurred (Wong et al., 2016).

### 3.3.3.1 Initial programme theory (IPT)

Constructing initial or candidate programme theories at the beginning of the evaluation process is crucial in realist evaluation (Pawson and Tilley, 1997b). Inductive reasoning and deductive reasoning are two common reasoning logic in research and evaluation (Heit and Rotello, 2010). Inductive reasoning involves drawing conclusions from observations, while deductive reasoning starts with existing theories to examine whether associations are consistent with expectations (Heit and Rotello, 2010). Both inductive and deductive approaches can be employed to formulate IPTs that describe a causal relationship, including literature review, stakeholder consultation, hunches and retroductive thinking (Funnell and Rogers, 2011, The RAMESES II Project, 2017a).

Implicated by the semantic notion of scientific realism, realists often employ abductive thinking to uncover the underlying mechanisms (section 3.2.2). A combination of inductive development, including interviews with stakeholders, and deductive development, including literature reviews, should be undertaken to embrace the richness of programme theory (Funnell and Rogers, 2011). Furthermore, abductive thinking should be employed when developing IPTs.

Regarding the presentation forms of IPTs, in Funnell and Rogers (2011), various forms were introduced: pipeline logic model, outcomes chain logic model, realist matrices, and narratives, etc. Realist evaluation studies typically use the 'if...then...because' statements and hypothetical Context-Mechanism-Outcome Configurations (section 3.3.4) to theorise IPTs (Westhorp et al., 2011, Doi et al., 2015, Wong et al., 2016). Notably, IPTs can remain in the 'if...then' format and then be unpacked to CMOCs during the data analysis phase (Jagosh et al., 2022).

Context, mechanism, and outcome are three core elements in programme theory in realist evaluation. It is assumed that complex programmes are influenced by the interplay between various contexts and mechanisms, leading to different outcomes. Programme theory plays a crucial role in articulating how different contexts interact with mechanisms to lead to intended or unintended outcomes and realist evaluation aims to unravel the programme theory that elucidates the generative causal relationships underlying the success or failure of a programme (Pawson and Tilley, 1997a, Pawson and Tilley, 1997b, Marchal et al., 2012, Wong et al., 2016). In the following sections, I will further define the three elements.

### 3.3.4 Context-Mechanism-Outcome Configurations (CMOCs)

No matter which methods are employed to formulate programme theories, it is critical to ensure that these theories accurately reflect the realist perspective on causation, which entails considering contexts and mechanisms and how they work collaboratively to produce outcomes within a programme (De Souza, 2013). CMOCs, as the fundamental causal explanatory framework in realist evaluation (Pawson and Tilley, 1997b), are employed by most realists to present programme theories.

### 3.3.4.1 Mechanism

'Mechanism' is put at the forefront because it is the tool most directly associated with stratified reality in realist evaluation (Pawson and Tilley, 1997b). Mechanisms exist constantly in the 'empirical' regardless of whether they are currently operating (Westhorp, 2014). Thus, what realists try to achieve is to explain how an intervention or programme works by going beneath the surface (observable entities) to explore underlying hidden mechanisms (The RAMESES II Project, 2017d).

Pawson and Tilley (1997b) defined programme mechanisms as the process of how a programme or intervention contributes to producing intended or unintended outcomes and argued that mechanisms inherent in a programme or policy are the resulting changes in individuals' decision-making processes referred to as "reasoning" caused by the "resources" offered to individuals. In other words, mechanisms that cause outcomes are the interactions between what a programme or intervention provides to individuals and their 'reasoning' in responding to the resources provided (Weiss, 1997). Thus, merely observing what a programme or intervention provides, such as programme components, is insufficient to capture the mechanisms, as it fails to account for individuals' responses (The RAMESES II Project, 2017d, Westhorp, 2014). To explain this, Dalkin et al. (2015) suggested changing the equation proposed by Pawson and Tilley (1997b) 'Context + Mechanism = Outcome' to the following diagram:



Figure 3.3 Revised CMO formula (Adapted from Dalkin et al. (2015))

The "reasoning" of the target population varies based on their social and cultural backgrounds (Westhorp et al., 2011, Westhorp, 2014). Individuals with diverse demographic factors and cultural and social backgrounds may exhibit distinct responses to identical programme resources. This is why the identical intervention

components may have different effects on different individuals, and it is realists' work to identify 'what works for whom'. Whether mechanisms will be activated or remain latent depends on 'contexts' (Pawson and Tilley, 1997b, The RAMESES II Project, 2017d).

#### 3.3.4.2 Context

'Context' in realist evaluation is defined as preexisting social rules, norms, values, and interrelationships in the programme's implementation places (Pawson and Tilley, 1997b). To explain the relationship between context and mechanism, Pawson and Tilley (1997b) wrote:

*"It is the contextual conditioning of causal mechanisms which turns (or fails to turn) causal potential into a causal outcome"* (p.69).

Contexts determine whether mechanisms will operate and which primary mechanism will operate among a set of mechanisms (Figure 3.2). This demonstrates that even if the same programme or intervention with the same 'resources mechanism' is implemented, different social and cultural backgrounds, demographic traits, and personal resource availability can trigger different mechanisms, leading to different outcomes (Figure 3.3).

Dealing with the complexity of contexts in realist evaluation is a challenge for researchers (Pawson, 2013). Through employing a philosophical perspective of critical realism, this realist evaluation study was conducted within an 'open system' where different entities interact and influence each other, leading to dynamic changes in the existing contexts that consequently influence the intended outcomes (The RAMESES II Project, 2017e). The RAMESES II Project (2017e) added that contexts not only include these social aspects but also encompass psychological, economic, and resource-related factors. These factors collectively form the 'contexts' that shape stakeholders' mechanism (reasoning) in response to programme resources, ultimately affecting programme outcomes.

Contexts and mechanisms are interrelated with each other and should not be considered in isolation, but rather bond together to explain how context influences mechanisms and subsequently shapes outcomes (Maxwell, 2012b). Realists should not only identify contextual factors but also employ analytical strategies to explore the interaction between contexts, mechanisms, and outcomes to construct CMOCs (Pawson and Manzano-Santaella, 2012).

### 3.3.4.3 Outcome

In realist evaluation, ‘Outcome’ is the actual impact or result produced by a programme or intervention, including both the intended and unintended impact. To have a comprehensive understanding of ‘Outcome’, the concept of ‘Change’ is essential. Change refers to how the original regularity (Section 3.2.3.3: open system) is altered to another regularity as a result of implementing a programme or intervention. To summarise, ‘Outcome’ is shaped by the change of regularities brought about by how different mechanisms operate in the context (Figure 3.4) Pawson and Tilley (1997b). Every social intervention or programme is designed to produce a change in initial ‘Regularities’.

The goal of realist evaluation is to find the social ‘Regularities’, ‘Outcomes’, and ‘Patterns’ in a programme or intervention, which are shaped by the interplay between contextual factors and underlying mechanisms (Pawson and Tilley, 1997b).

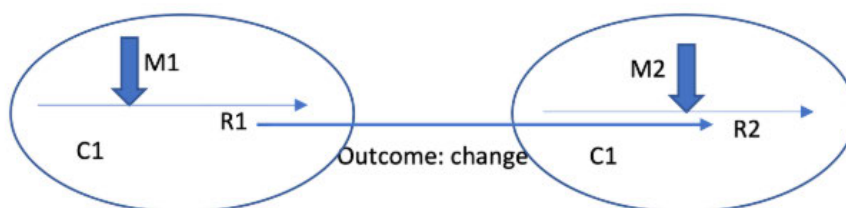


Figure 3.4 Change in regularity result in outcome (Adapted from Pawson and Tilley (1997b))

### 3.3.5 Implications for research design

It should be noted that realist evaluation draws from both scientific and critical realism, so this study also drew on both to guide how the research is undertaken (Mukumbang et al., 2023) (Table 3.3).

	<b>Implications for realist evaluation</b>	<b>Contributions to the current research</b>
	<b>Critical Realism</b>	
Stratified reality (section 3.2.3.1)	Recognise the complexity of multiple levels of causation: individual level, organisational level, social level etc.	Describe any observed events that happen to smokers to promote smoking behaviour change.
Embeddedness (section 3.2.3.2)	Social phenomena are not isolated or independent entities, but are deeply rooted within a larger social, economic, and historical context in diverse subjects.	Description and explanation of outcomes based on specific environmental contexts e.g. When a Chinese smoker stop using cigarettes for social interactions, it demonstrates that they have developed the awareness of the risks of smoking and the drawbacks of cigarette gifting culture (Chapter 2)
Open system (section 3.2.3.3)	Recognise that the world is an open system that is continually shaped and influenced by external forces, including social, cultural, economic, and environmental factors.	<ol style="list-style-type: none"> <li>1. Identify the relationships between Contexts, Mechanisms, and Outcomes.</li> <li>2. Different opinions from participants may provide evidence for refinement of IPTs.</li> </ol>
	<b>Scientific Realism</b>	
Semantic notion (section 3.2.2)	Scientific theories should be understood as providing true or approximately true descriptions of the independently existing world.	Starts from common sense and abductive thinking to formulate IPTs (if...then statements)
Epistemic notion: 'no miracles'	Recognise that the best explanation among a set of candidate explanations is most likely to be true.	Effective programme theory should have explanatory power and predictive success as they are more likely to be true or

argument (section 3.2.2)		approximately true to provide a description of the real world
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Table 3.3 Contributions of critical realism and scientific realism to this study

Having introduced the definitions of the three elements in programme theory and how critical realism and scientific realism contribute to realist evaluation, it is essential to outline the stages of realist evaluation research. Pawson and Tilley (1997b) use the following figure to show the cyclic process of realist evaluation:

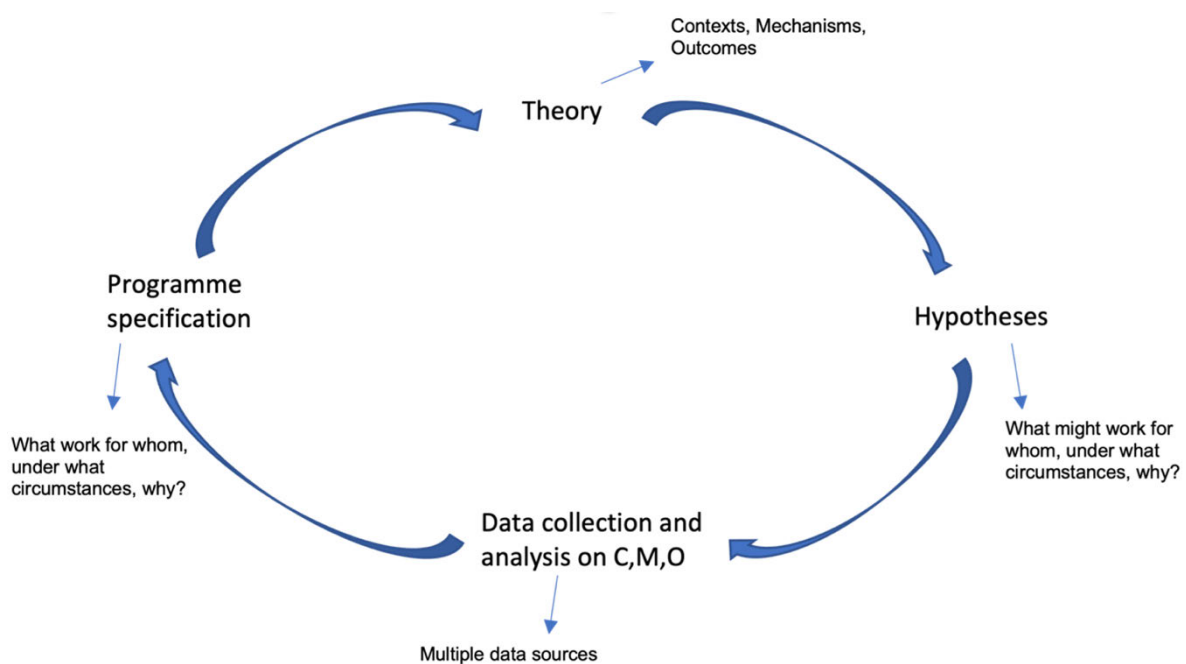


Figure 3.5 Realist evaluation cycle (Adapted from Pawson and Tilley (1997b))

As explained in section 3.3.3, realists aim to articulate programme theory to explain how an intervention or programme works. This process often starts with formulating IPTs (section 3.3.3.1), followed by testing these IPTs with different stakeholders. The final stage involves realist data analysis and refinement of the IPTs, leading to the development of refined programme theories, which proceeds by comparing the data with initial CMOCs deductively and identifying new elements of programme theories inductively (Jagosh et al., 2022).

The development of IPTs, including who could contribute data to its development should be matched with the complexity of the programme or intervention and a

mixture of inductive and deductive approaches (Funnell and Rogers, 2011). In the next sections, I will explain the different stages of this study informed by realist evaluation methodology, including methods chosen for data collection, data analysis and interpretation.

### 3.4 Research stages

Before introducing the research stages, it is beneficial to emphasise the research aim of this study again. This study aims to examine what aspects of smoking cessation apps work for Chinese smokers, under what circumstances, and how. Thus, realist evaluation was chosen as the methodology of this study based on its ontological depth, enabling the exploration of the underlying mechanisms and contextual factors that determine the success or failure of complex interventions, such as smoking cessation apps.

This study is composed of three stages:

1. Formulating IPTs: Two systematic reviews and interviews with Chinese health workers were undertaken to formulate IPTs. I will explain the contributions of each review and the interviews to the formulation of IPTs in Section 3.4.1.
2. Testing IPTs: Interviews were conducted with Chinese smokers who have used smoking cessation apps before. At this stage, each construct of initial CMOCs were tested. The interview data informed the decision of whether to accept, refine, or refute IPTs.
3. Refinement of IPTs to refined programme theories: Realist data analysis and refinement of the IPTs led to the development of refined programme theories by deductively comparing the data with initial CMOCs and inductively identifying new elements of programme theories from interview data (smokers). The refined programme theories offer explanations of what aspects of smoking cessation apps work for whom (outcomes), under what circumstances (contexts), and how (mechanisms).

### 3.4.1 Stage one: Formulating IPTs

In section 3.3.3.1, various approaches to formulating IPTs were presented. In this study, I conducted two systematic reviews and interviews with health workers to identify different contexts, mechanisms, and outcomes, using abductive thinking to formulate IPTs.

#### *3.4.1.1 Qualitative systematic review (1<sup>st</sup> systematic review)*

When evaluating smoking cessation apps, the primary stakeholders are the app users, and their perspectives regarding apps form a significant part of the contexts in which apps operate. Smokers' experience of using smoking cessation apps can serve as an indicator of how users interact with and perceive various app features and characteristics, shedding light on the underlying mechanisms through which these apps help smokers stop smoking. Therefore, a qualitative systematic review was undertaken to explore contexts and mechanisms in smoking cessation apps (Chapter 4). This review also summarised effective app features and characteristics of smoking cessation apps in aiding smoking cessation and discussed potential improvements in the design of these apps.

#### *3.4.1.2 Systematic review of RCTs (2<sup>nd</sup> systematic review)*

This second systematic review aimed to identify outcomes of using mHealth interventions to stop smoking. Instead of only focusing on smoking cessation apps, it provides a broader context, helping to understand what influences the effectiveness of mHealth interventions in smoking cessation. While the first review focused on smokers' perspectives, revealing potential IPTs by examining their needs and experiences, the second review enhanced the IPTs from the standpoint of the effectiveness of mHealth interventions in smoking cessation. The findings were used to complement the first qualitative systematic review to explain how mHealth interventions in smoking cessation work in empirical evaluations.

#### *3.4.1.3 Health workers interviews*

Ensuring that any IPT formulated was relevant to the Chinese context was necessary. In line with this, the last step of formulating IPTs was to conduct realist

interviews with health workers who have regular interactions with smokers. Eligible participants included health workers in respiratory departments in hospitals or smoking cessation clinics. The reasons why they are regarded as key stakeholders include: (1) they are keen to employ various interventions, including smoking cessation apps to help smokers quit smoking; (2) they possess professional knowledge and expertise in dealing with smoking-related issues and cessation treatments; (3) they may have experienced smokers who have used smoking cessation apps before so they may also be aware of comparisons between smoking cessation apps and other smoking cessation interventions; (4) they can provide information about the Chinese context-specific challenges and common barriers among Chinese smokers. By including these stakeholders, this study was able to identify contextual factors, including cultural and social factors, that influence the success or failure of smoking cessation apps in China.

#### 3.4.1.3.1 Recruitment of health workers

I contacted two hospitals (hospital A in an urban city and hospital B in a rural city) and one smoking cessation clinic, which had cooperation with hospital A. The ethical approval from Hospital B was obtained and submitted to the University of Edinburgh ethics committee. Hospital A and the smoking cessation clinic did not require or have any formal ethical procedures in place. Therefore, after consulting the academic contact who introduced me to hospital A and the smoking cessation clinic (I will reflect on this in Chapter 9), I was suggested to seek oral permission from the head of the respiratory department at hospital A and the owner of the smoking cessation clinic.

After ethical approval from the University of Edinburgh (Appendix 1) was obtained, a recruitment poster was displayed at hospital A, hospital B, and the smoking cessation clinic. Hospital A and the smoking cessation clinic are located in Wuhan, and hospital B is situated in Huaibin. Wuhan is the largest provincial capital city in the central region of China (Hubei Province Government, 2024), while Huaibin is a small county town (Xinyang Bureau of Statistics, 2024). The goal of selecting two hospitals in Wuhan and Huaibin was to gain insights from the perspectives of health workers in both urban and rural areas in China. Information sheets (Appendix 2)

were provided to potential participants, and they were encouraged to ask any questions or express their concerns before deciding to participate. Once they confirmed their participation, the consent form (Appendix 3) was provided and signed in person before the interviews took place.

#### 3.4.1.3.2 Semi-structured interviews with health workers

Six health workers were interviewed at this stage. Interviews with health workers were conducted from September 2021 to March 2022 (including applying for ethical approval from Chinese hospitals, asking for permission from gatekeepers, recruitment, and conducting interviews). The duration of interviews ranged from 35 to 60 minutes.

Unstructured interviews and semi-structured interviews are common interview types for qualitative researchers to gather rich data from interviewees (Brinkmann, 2014). Unstructured interviews are more appropriate for researchers with limited knowledge about the topic (Brinkmann, 2014). In addition, it is difficult for researchers to guide the direction of interviews using an unstructured interview approach (Creswell and Poth, 2018). Therefore, unstructured interviews were inappropriate for the current study as the purpose of interviews with health workers was to gain their perspectives on smoking cessation contexts and smoking cessation apps used in China. Adopting semi-structured interviews was considered more appropriate in this study because it enabled me to use the pre-designed interview guide to direct the interview process (Brinkmann, 2014). In addition, adopting an interview guide allowed me to keep the entire interview process focused more on core issues without straying too far off track (Adams, 2015). Moreover, semi-structured interviews allow for flexible dialogue between the interviewer and interviewee (Brinkmann, 2014). Despite having an interview guide, the conversation is not limited to fixed questions, so it allows for producing richer and more comprehensive insights (Creswell and Poth, 2018). The interview guide (Appendix 4) for health workers was designed based on the findings of the two systematic reviews and sent to supervisors for feedback. The interview guide was then tried with another PhD student who had experience conducting realist interviews to practice my interview skills and ask questions like a realist.

A realist interviewing approach was employed (Manzano, 2016). The interviews began with general questions, such as their experiences with treating smokers and their perspectives on the possibility of mHealth in changing addictive behaviours. Then, the interviews delved into more detailed and exploratory questions, such as their perspectives and expectations regarding specific features of smoking cessation apps. The interview guide used open-ended questions so interviewees could propose their perspectives on the core questions, and it also allowed me to ask follow-up questions to clarify their meanings further (Weller et al., 2018).

The “learner-teacher cycle” was adopted in realist interviews (Manzano, 2016). Pawson (1996) advocates that theory-driven interviews should be a continuum that follows the ‘learner-teacher cycle’ approach. In other words, the researcher first educates the interviewees about the theory constructs being tested, including specific components of the programme, and the interviewees then provide their comments and opinions regarding the provided theories and the identified constructs. During realist interviews, teacher and learner roles became interchangeable between the interviewer and the interviewee. While qualitative researchers use structured, semi-structured or unstructured interviews to explore concepts (Weiss, 1995, Warren, 2002), realist researchers tend to ask for propositions (Pawson, 1996). For example, when asking about the relationship between user engagement on apps and smoking cessation outcomes, qualitative researchers may ask, ‘Do you think engaging more on apps could enhance smoking cessation motivation and why?’ However, a realist researcher may ask, ‘Some smokers think a higher engagement level of smoking cessation apps means they are focusing on smoking cessation, and this high engagement level can lead to a higher success level. What is your thought on it?’.

The interviews with health workers were conducted in person in the respiratory departments of the hospitals (the health worker from the smoking cessation clinic was also invited to the respiratory department of hospital A). The head of the respiratory department provided us with an office to conduct interviews. Adhere to the ethical application, an encrypted recorder was used to record interviews. Audio files of interviews, interview transcripts and any files containing information about them were stored securely on the University’s OneDrive. This folder was password-

protected, and only I could access it. All interviews were transcribed verbatim by me. Once transcription was finished, audio files were deleted permanently.

#### 3.4.1.3.3 Data analysis of interviews with health workers

Thematic analysis was employed to analyse the interview data (Braun et al., 2019). One of the benefits of thematic analysis is its flexibility since it is independent of theory and epistemology (Braun and Clarke, 2019). When exploring the literature, three approaches of thematic analysis were identified: code reliability, codebook, and reflexive (Boyatzis, 1998, Braun et al., 2019). Code reliability prioritises the measurement of coding reliability through the use of structured and fixed codebooks. Codebook approaches, such as framework analysis (Gale et al., 2013), also use fixed codebooks, but they emphasise qualitative research values rather than counting the numbers that codes emerge. The reflective thematic analysis has flexible coding processes without using codebooks (Braun and Clarke, 2019). Individual codes can evolve or change the boundary during the coding process and can be split into several codes (Braun and Clarke, 2013).

Codebook thematic analysis uses a structured codebook but has the qualitative underlying philosophy of reflexive thematic analysis (Braun et al., 2019). Compared with the code reliability approach, it has more flexibility because themes can shift and change and be developed through the coding process. In addition, I had expected that a list of initial deductive codes would be identified from the findings of systematic reviews (for health workers' interview data) and IPTs (for smokers' interview data). Therefore, the codebook thematic analysis approach was chosen to analyse the qualitative interview data. Figure 3.6 presents the detailed data analysis process at this stage.

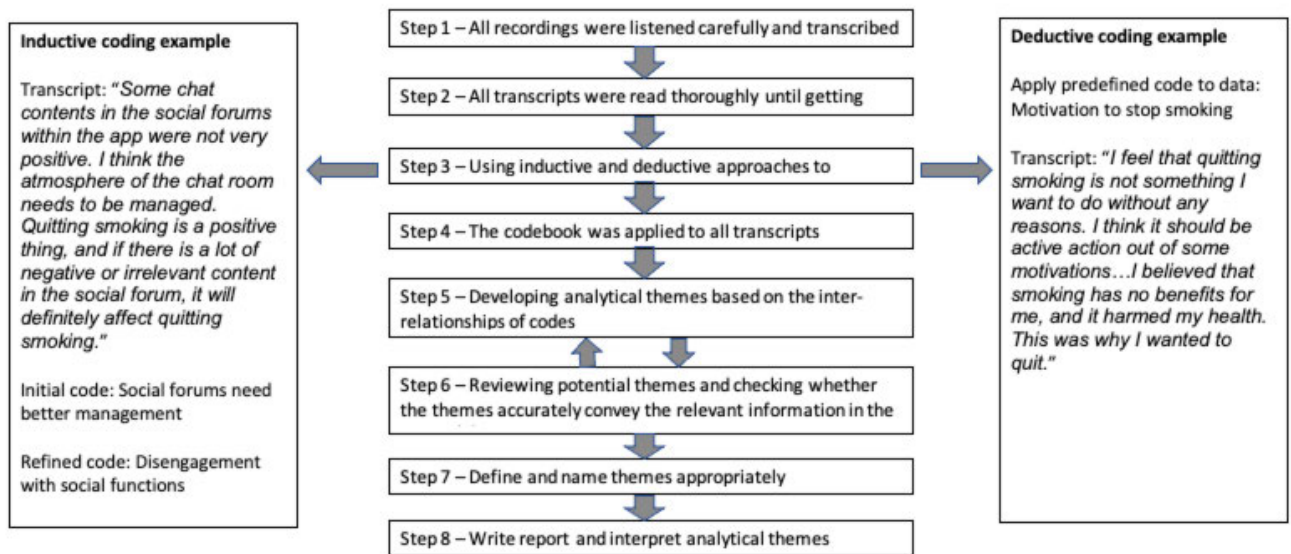


Figure 3.6 Thematic analysis process Adapted from Nowell et al. (2017)

To avoid redundant descriptions, the step-by-step analysis of interview data will be presented in Section 3.4.3, together with the analysis of interviews with smokers.

### 3.4.2 Stage two: Testing IPTs

The second stage of this study is to test the formulated IPTs through semi-structured interviews with Chinese smoking cessation app users because their experience and perspective of using apps were deemed crucial in terms of providing valuable causal insights into how these apps bring about changes to assist them to stop smoking (Pawson and Tilley, 1997b).

#### 3.4.2.1 Recruitment of smokers

To be eligible for this study, the recruited Chinese smokers must have the experience of using smoking cessation apps. The advertisement poster, which elucidated research details, including aims, eligibility criteria, and contact information, was posted on Chinese main social media platforms. Interested smokers who contacted me were sent the electronic information sheet (Appendix 5) in the Chinese version to ensure they clearly understood their rights and obligations before deciding whether to participate in the study. Before they made the decision to participate, I also allowed them to ask any questions or express their concerns.

Those who agreed to participate were then sent an electronic consent form (Appendix 6) and asked to sign it to confirm participation. Since participants came from different regions of China and Covid-19 restrictions were in place at that time, all interviews with smokers were conducted online through phone calls via WeChat (the main social media platform in mainland China). The interview data and time were scheduled once they returned the electronic consent forms.

Interviews and recruitment were conducted concurrently (Morse, 1995). In traditional qualitative inquiry, it is often recommended to have a smaller sample size compared with quantitative studies, although the specific number cannot be predetermined (Morse, 1995). During this phase, interviews typically continued until all constructs of IPTs were tested and no new insights emerged from them (Fusch and Ness, 2015). Overall, 24 Chinese smokers were recruited and interviewed for the testing stage.

#### *3.4.2.2 Semi-structured interviews with smokers*

Interviews with smokers were conducted from May 2022 to January 2023 (including recruitment and interviews). The duration of the interviews ranged from 40 to 80 minutes. The realist interviewing approach was employed for interviews with smokers (Section 3.4.1.3.2).

The interview guide was designed based on the initial CMOCs (Chapter 6) (Manzano, 2016). When starting realist interviews, some general questions about interviewees' overall views on the intervention and their experiences should be asked first. Then, follow-up questions about specific experiences or issues related to the intervention could be asked based on their responses. This helps to understand the interviewees' genuine perspectives and facilitates a deeper discussion on how the intervention helps them achieve the intended outcomes (Seidman, 2006). Therefore, before asking them the constructs of initial CMOCs, some introductory questions, such as 'When did you start smoking and why did you start smoking?', 'Could you tell me the overall impression of the smoking cessation app you are using now?' The logic was shown in the interview guide to guarantee that the interview questions covered all IPTs. The interview guide for smokers is shown in Appendix 7.

Similar to interviews with health workers, audio recordings of smokers' interviews were made using an encrypted recorder and stored in the password-protected OneDrive. Once transcription was finished, the audio files were deleted permanently.

### 3.4.3 Step-by-step analysis of interview data (health workers and smoker interviews)

The rationale for choosing codebook thematic analysis to analyse interview data is explained in Section 3.4.1.3.2. The data analysis process is presented in Figure 3.6. I used NVivo to assist with the data analysis process (QSR International, 2018). NVivo is a software that helps researchers analyse and manage qualitative data, such as interview transcripts. NVivo allows me to iteratively review existing codes, combine them into themes, or split them into subthemes. Notably, the coding process was conducted based on the original Chinese transcripts. This was to avoid a lack of comprehensive understanding or misinterpretation of the interviewees' genuine meanings (Temple and Young, 2004, Squires, 2009).

#### 3.4.3.1 *Get familiar with the interview data (steps 1 and 2)*

Steps 1 and 2 involve getting familiarised with the interview data. As shown in Figure 3.6, I listened to all recordings carefully and transcribed them verbatim to familiarise myself with and understand the discussed issues before they were analysed. Then, all transcripts were imported to NVivo as separate files. Before starting to develop the codebook, I read all transcripts thoroughly to familiarise myself with them.

#### 3.4.3.2 *Development and application of codebook (steps 3 and 4)*

Braun and Clarke (2006) described that the coding process in thematic analysis can be deductive and inductive. Inductive coding is data-driven, which means themes come from the data itself (Braun et al., 2019). On the other hand, deductive coding is driven by pre-existing theories and research questions (Braun et al., 2019).

For interviews with health workers, deductive codes were generated from the findings of two systematic reviews (Chapters 4 and 5). Inductive codes were identified from the interview data. For interviews with smokers, the deductive codes came from initial CMOCs (Chapter 6), while inductive codes were also identified from the interview data.

To ensure the development of a high-quality codebook, the codebook development process (health worker interviews and smoker interviews) began with coding two transcripts together with another PhD student from the School of Health in Social Science and checking consistency. I translated the selected two transcripts into English before sending them to the co-coders. After coding the selected two transcripts separately, the results were compared to ensure that all codes conveyed an accurate meaning and that no important information was missed.

Notably, when developing the codebook for smoker interviews, all HCI-related data, such as usability and user experience, were sent to another PhD student from the School of Informatics to build the HCI-related codebook before the codebook was applied to all transcripts. The reason why this step was not applied when developing the codebook for health worker interviews was that the recruited health workers were not necessarily to be smoking cessation app users, so limited information on usability and user experience was found in these transcripts. The recruited health workers mainly talked about their perspectives on the challenges and barriers for Chinese smokers to stop smoking and their expectations of app features and characteristics.

After completing the coding for the selected two interview transcripts, the English transcripts and the codebook were sent to supervisors for review. Any inaccurate or ambiguous codes were discussed and resolved at the supervision meeting. The final version of the codebook was then applied to the remaining transcripts.

#### *3.4.3.3 Developing analytical themes (steps 5 and 6)*

After applying the codebook to all transcripts, initial codes were then categorised into analytical themes based on their inter-relationships. Then, in step 6, all analytical themes developed in step 5 were reviewed and checked for accuracy through original transcripts. Notably, steps 5 and 6 are iterative, meaning the identified themes in step 5 were returned to the original transcripts to check if they accurately convey the interviewees' meanings. This process was repeated until all themes clearly and accurately summarised the original content. Table 3.4 shows an example

of how the coding process progressed and how the interrelated codes were categorised together to form themes.

Theme	Subtheme	Original transcripts	Initial codes
Motivation for smoking cessation	Intrinsic motivation	<p>MZ: <i>Some smokers prefer to receive positive information in apps, such as the benefits of smoking cessation or the progress of smoking cessation, rather than negative information. What is your opinion on it?</i></p> <p>Interviewee 02 (smoker): <i>No matter how terrifying the consequences of smoking are, they can't compare to the terror of being without cigarettes during moments of craving. That's why it's important to discuss the benefits of quitting smoking... I derive a lot of happiness and joy from smoking. Why quit smoking? I have not experienced health issues from smoking and the absence of cigarettes would make me feel worse, right?</i></p>	<p>fear of losing the accompany of cigarettes</p> <p>lack of motivation to stop smoking</p> <p>deny the severity of smoking</p>
	Extrinsic motivation	<p>MZ: <i>Some smokers mentioned that the daily check-in function can motivate them to keep abstinent. Do you have this feeling? Could you share your own experience of using this function?</i></p> <p>Interviewee 13 (smoker): <i>I find this function useful because, as the number of smoke-free days increases, I feel my efforts are paying off. Seeing the days add up, my health index improving, and the financial saving, really motivates me. Another motivating aspect of the app is the military rank system it employs. As time progresses, my rank increases, and currently, I hold the rank of a commander. This sense of achievement and progress further motivates me to keep abstinence.</i></p>	<p>feel smoking cessation efforts paid off</p> <p>viewing the progress of smoking cessation can be motivating</p> <p>getting upgraded in the rank system is motivating</p>

Table 3.4 Example of the coding process and developing analytical themes

#### *3.4.3.4 Naming, interpreting, and presenting themes (steps 7 and 8)*

All themes were named and defined appropriately and presented in Chapters 6 (health worker interviews) and Chapter 7 (smoker interviews). Screenshots of exported themes from NVivo were presented in Appendix 8 (health worker interviews) and 9 (smoker interviews).

Codes and themes were named in English, and all extracted quotes in this thesis were translated into English. Themes identified from health worker interviews were used to identify additional contexts, mechanisms, and outcomes that were not identified in two systematic reviews. Four IPTs were formulated by combining the findings of two systematic reviews and health worker interviews (Chapter 6).

Data analysis of smoker interviews is the way to interrogate the IPTs with data and understand data patterns using theories (Wong et al., 2017). Overall, the data analysis approach in realist evaluation should be retroductive, which moves between inductive and deductive processes (Wong et al., 2017). The analytical themes of smoker interviews (Chapter 7) were used to explain the aspects of identified programme theories and provide a detailed explanation of how different intended and unintended outcomes were produced by the interplay of contexts and mechanisms (Gibbs et al., 2022, Graham et al., 2023, Hoens et al., 2022). This stage involved comparing the findings with the CMOCs from the IPTs deductively and identifying new theories inductively (Yin, 2009). The inductive data analysis uncovered additional contexts, mechanisms, and outcomes not identified in initial CMOCs. This process resulted in eleven CMOCs (Chapter 8).

#### *3.4.4 Stage three: Refinement of programme theories*

The final stage of this study was to refine the programme theories based on the interview data and to provide a plausible explanation of how specific contexts and mechanisms interact to produce different intended and unintended outcomes in smoking cessation apps for Chinese smokers. The process of IPT refinement progressed through the iterative cycles between refined CMOCs and original

transcripts to check the accuracy and the causal relationship. The refined programme theories using CMOCs will be presented in Chapter 8.

The refined programme theories provided insights into how to improve smoking cessation apps by explaining what works for whom (outcomes), under what circumstances (contexts), and how (mechanisms). Specifically, the refined programme theories provided a detailed explanation of important contextual factors for the success of smoking cessation apps, enabling and disabling mechanisms, and intended and unintended outcomes. Based on the refined programme theories, this evaluation set out implications for practice, including health practitioners and app developers, for research and policy (Chapter 9).

### 3.5 Ethical considerations

The ethical approval (Appendix 1) and a sponsorship letter (Appendix 10) for this study were granted by the University of Edinburgh. The ethical approval issued by the School of Health in Social Science at the University of Edinburgh covered all research details, including recruitment approaches, data collection and protection methods. Three main ethical issues were important for the empirical study: (1) respect for participants, for example, privacy and consent; (2) beneficence and non-maleficence; and (3) guarantee each participant is treated equally (Beauchamp, 2003, Creswell and Poth, 2018).

#### 3.5.1 Respect for human Autonomy and privacy

Information sheets (Appendix 2,5) for health workers and smokers, which contain research aims, methods, how the data will be stored and used, and potential benefits or risks, were designed and sent to potential participants before they confirmed participation. To confirm their participation in this study, participants should have been informed about the research details, including aims and procedures, the reasons for their eligibility, what information will be collected from them, and how their information will be stored and used. Once participants understood their rights and obligations, they were given the consent form to sign (Appendix 3,6).

It was guaranteed that there would be no coercion during the research. Potential participants could decide whether to participate in the study and were informed that they could decide to end their participation at any time without giving reasons. In this study, all participants who signed the consent form attended the interview. The contact information was presented in the recruitment posters and information sheets, which meant potential participants could ask questions or express their concerns before participating.

Confidentiality was considered during data collection and analysis. An encrypted recorder was used to record online interviews (phone calls via WeChat). WeChat is one of mainland China's most popular social tools for instant text and voice messaging communication (Wu, 2014). Although it was explicitly stated in the information sheets that the interviews would be recorded, I reminded participants about this before each interview started. The interview transcripts were stored securely in the University's OneDrive. This was password protected, and only I could access materials in it. Any identifiable information, such as names, was anonymised or replaced using numbers during data analysis. For example, all participants were assigned a number, and only the numbers would be presented in this thesis, such as Health Worker 01.

### 3.5.2 Beneficence and non-maleficence

I tried to maximise the benefits and minimise the risks and hazards to the participants. All potential benefits, risks, and harms were presented in the information sheets. Participants decided whether to participate based on their assessment of the balance of benefits and harms. One potential risk for smoker interviewees is being labelled as "smokers" or "ex-smokers" (Tudor-Sfetea et al., 2018). Another potential risk for smokers would be emotional stress during interviews because the interview topic might remind them of past smoking cessation experiences, especially for smokers who had failed attempts before.

### 3.5.3 Justice

Throughout the research process, all participants were treated fairly, and their contributions to the research were acknowledged in the Acknowledgement in this thesis.

### 3.6 Summary

This Chapter outlines the methodology and research stages, beginning with an introduction to the philosophical aspects underpinning the study. This includes a discussion on realism and key tenets of critical realism and scientific realism. Then I distinguish realist evaluation from other evaluation types by exploring generative causation, theory-driven evaluation, and programme theory, with a focus on constructs in programme theory, including contexts, mechanisms, and outcomes. Subsequently, the three stages of this study are detailed, including the process of formulating, testing, and refining programme theories. Lastly, the chapter presents how ethical issues were considered, such as respect for autonomy and privacy, beneficence and non-maleficence, and justice. In the next chapter, I will present the qualitative systematic review, which is the first step in formulating IPTs.

## CHAPTER FOUR: A qualitative systematic review of user needs and user experience of smoking cessation apps

### 4.1 Introduction

This chapter presents the first systematic review published in the *International Journal of Medical Informatics* in 2023, which is formatted according to the university's guideline for including published articles in a PhD thesis. The content and structure (including table and figure names) of the published paper have remained unchanged. Only an introduction and conclusion paragraphs have been added to clarify the contribution of this published systematic review within the entire thesis.

Before presenting this published systematic review, I hereby confirm that all review authors, Maria Wolters (MW), Siobhán O'Connor (SO), Yajing Wang (YW), Lawrence Doi (LD), and myself (MZ) retain the copyright of the article. The full publication is attached in Appendix 11 and can be freely accessed through <https://www.sciencedirect.com/science/article/pii/S1386505623000874>. I took the lead in writing the entire paper manuscript. Other authors (MW, SO, LD) contributed to providing suggestions on addressing reviewers' comments.

As outlined in Chapter 3, this realist evaluation was composed of three stages: formulating IPTs, testing IPTs, and refinement of IPTs to the refined programme theories. The first step in stage one to formulate IPTs is to conduct this first qualitative systematic review. It identified user needs and user experience on common app features and characteristics, which often acted as contexts, resource mechanisms, and reasoning mechanisms in smoking cessation apps.

### 4.2 Published paper manuscript

#### 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 (WHO, 2021). 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 (WHO, 2021).

With the growth of mHealth, in particular during the Covid-19 pandemic, mobile apps have been increasingly adopted as an aid to smoking cessation (El-Toukhy, 2021, Alqahtani et al., 2021). 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 (Struik et al., 2019, Paay et al., 2014). Apps can be used for short interactions with counsellors, if needed (Paay et al., 2015c), provide just-in-time support when smokers need it (Naughton, 2017, Schick et al., 2018), or be integrated with face-to-face counselling (Barroso-Hurtado et al., 2021).

Several literature reviews have examined aspects of mobile smoking cessation interventions (Whittaker et al., 2010, Whittaker et al., 2016, Ghorai et al., 2014, Haskins et al., 2017, Thornton et al., 2017, Barroso-Hurtado et al., 2021).

Ghorai et al. (2014) 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. (2014) 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 (Whittaker et al., 2010, Whittaker et al., 2016) also found evidence of potentially positive effects, although there was significant unexplained heterogeneity. Again, the interventions were predominantly text 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. (2021) 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. (2017) investigated the quality of 112 apps using two criteria: adherence to the Australian smoking cessation treatment guidelines (Zwar et al., 2011) and overall quality as rated using the Mobile App Rating Scale (Stoyanov et al., 2015), 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. (2017) 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” (ISO, 2019). 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 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).

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Database	Search terms
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CINAHL PLUS (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 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.

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MEDLINE ("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.

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PsycINFO ("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

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	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	("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	smok* OR vape* OR e-cigarettes stop* OR quit* OR cessation OR behave*
IEEE Xplore	(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)

**Table 1: Search terms used within electronic databases**

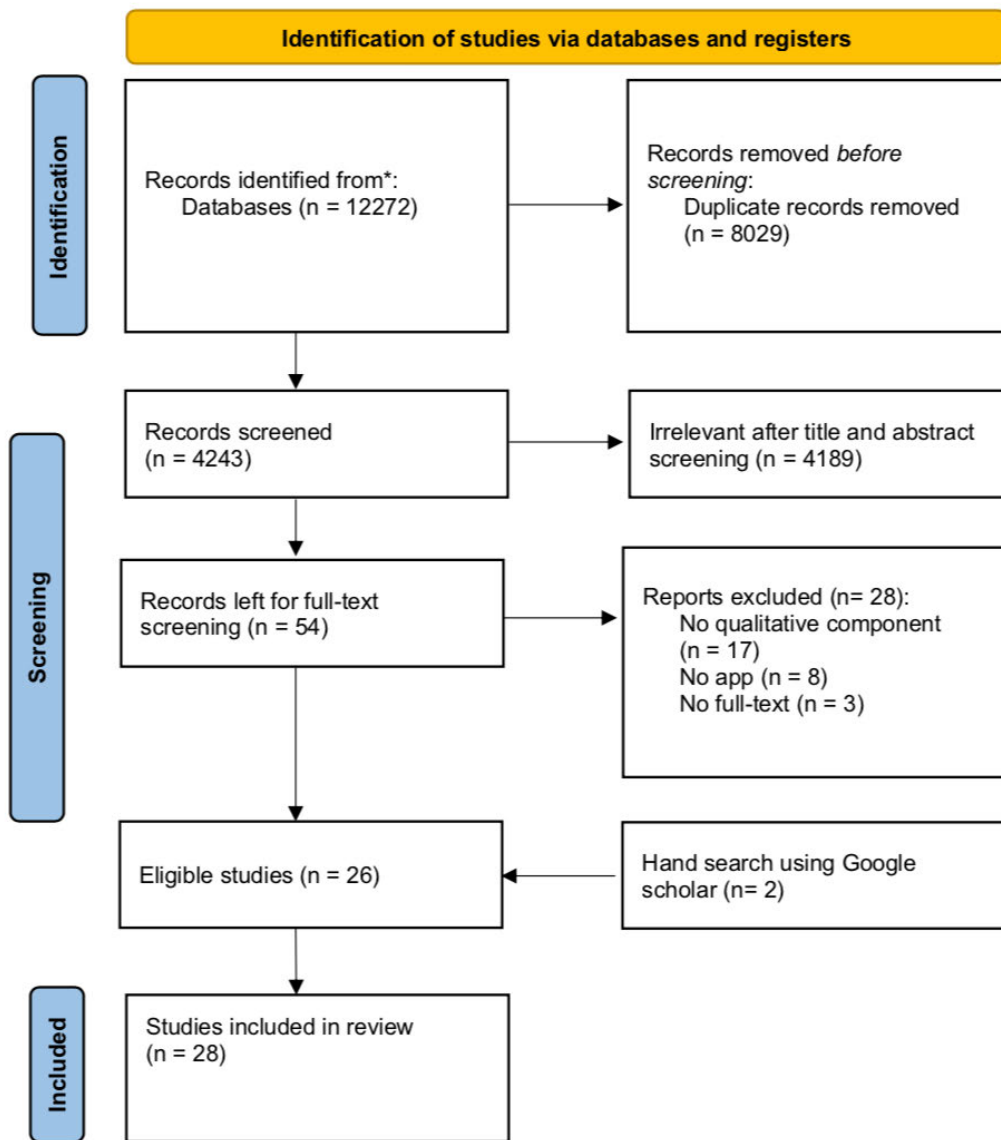
## 2.2 Inclusion and Exclusion criteria

Inclusion and exclusion criteria using the Population, Intervention, Comparison, Outcome (PICO) framework (Scells et al., 2017) are provided in Table 2.

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

**Table 2: Inclusion and Exclusion criteria**



**Figure 1: PRISMA flowchart of the screening process**

### 2.3 Study selection

Study selection was conducted individually by two reviewers (MZ and YW). Covidence (Covidence, 2021) 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 Figure 1. There were 12272 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 (Tong et al., 2012).

## 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 (Krippendorff, 2019). 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. (2020), who explored the overall attitudes toward smoking cessation apps and preferences regarding app design, and Bendotti et al. (2022), 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. (2022) 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 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 (Bendotti et al., 2022, El-Hilly et al., 2016, Wu et al., 2017), one examined a commercial app (Paay et al., 2015b), and one study did not explore a specific app (Gowarty et al., 2020).

The details of included papers are shown in Table 3.

No	Author / Year / Country	Research aim / Setting / Quality	Methods	Population	Smoking Cessation app and sources	Research-based apps	Findings (qualitative)
1	Armin et al. (2017)/ USA	<b>Aim:</b> To gain users' opinions to refine app content. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative descriptive design. <b>Data collection:</b> Focus group, Questionnaire, User testing. <b>Data analysis:</b> 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.	<b>YES</b>	<b>Users wanted the app:</b> 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. <b>Users liked the app:</b> 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. (2018a)/ Canada	<b>Aim:</b> To describe the process of developing Crush the Crave (CTC) and to evaluate the effectiveness of this app. <b>Setting:</b> Not reported.	<b>Design:</b> Five iterative cycles: listen, plan, do, act, and study using a STAR model. <b>Data collection:</b> Focus group. <b>Data analysis:</b> 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	<b>YES</b>	<b>Users wanted the app to cover:</b> 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.
3	Bendotti et al. (2022)/ Australia	<b>Aim:</b> To explore the opinions and experiences of Android and Apple mCessation app	<b>Design:</b> Mixed methods approach by collecting (1) qualitative data via a targeted search strategy to identify user reviews;	N/A	Forty-eight versions of 42 apps met eligibility criteria.  Sources: N/A	<b>NO (Apps in Google Play and Apple Store)</b>	<b>Users liked the app:</b> 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

		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. <b>Setting:</b> Not reported.	(2) quantitative data via MARS and user star ratings to determine mean objective and subjective ratings of app quality. <b>Data collection:</b> 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) <b>Data analysis:</b> Thematic analysis			communities or message boards to enhance support; 6. Can interact with other social media apps.  <b>Users wanted the app:</b> 1. Personalisation; 2. Functionality; 3. Relationality; 4. Credibility
4	EI-Hilly et al. (2016) / UK	<b>Aim:</b> To investigate how the gamification of mHealth interventions leads to a change in health behaviours, especially smoking behaviour. <b>Setting:</b> Not reported.	<b>Design:</b> A qualitative longitudinal study. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 6-phase analytic framework.	Adult smokers (N=16), 11 males, 5 females.	Puff away / Kwit 2  Sources: N/A	<b>NO (Downloaded from App Stores)</b>  <b>Users wanted the app to be:</b> 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. (2018)/ UK	<b>Aim:</b> To present a series of steps undertaken during the development of Cigbreak, a	<b>Design:</b> 7-stage design. <b>Data collection:</b> Focus group. <b>Data analysis:</b> Thematic analysis.	Adult smokers (N=73), 34 males and 39 females.	Cigbreak  Sources: A group of clinicians, researchers, and	<b>YES</b>  <b>Users wanted the app to cover:</b> 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,

		gamified smoking cessation app. <b>Setting:</b> University.			game developers, in collaboration with end users developed the app, which included gamification and theoretically validated Behaviour Change Techniques.		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. (2018)/ UK	<b>Aim:</b> To translate behaviour change technique concepts into digital content within the app. <b>Setting:</b> Not reported.	<b>Design:</b> Participatory design focusing on person-centred approaches. <b>Data collection:</b> “Think aloud” session. <b>Data analysis:</b> 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	<b>YES</b>	<b>Users liked the app:</b> 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. <b>Users disliked the app:</b> 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. <b>Users wanted the app to cover:</b> 1. Had a trustworthy logo, such as NHS; 2. Added a booking function sent an automatic appointment to the user’s outlook or other phone calendar.
7	Gowarty et al. (2020)/ USA	<b>Aim:</b> To explore attitudes toward smoking cessation apps and preferences regarding app design in young adult smokers with serious mental illness. <b>Setting:</b> A community mental health care.	<b>Design:</b> An exploratory qualitative study <b>Data collection:</b> Focus groups <b>Data analysis:</b> Thematic analysis	Adult smokers with serious mental illness (N=22), 10 females.	N/A	<b>N/A</b>	<b>Users wanted the app:</b> 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. (2021)/ USA	<p><b>Aim:</b> To determine the user experience, usability, and acceptability of QuitGuide and quitSTART—among young adult tobacco users with severe mental diseases.</p> <p><b>Setting:</b> A community mental health centre.</p>	<p><b>Design:</b> Mixed method approach</p> <p><b>Data collection:</b> Semi-structured interviews.</p> <p><b>Data analysis:</b> Thematic analytical techniques.</p>	Adult smokers receiving mental health treatment: Adult smokers (N=17), 7 females, 10 males.	QuitGuide / quitSTART	YES	<p><b>Users liked the app:</b> 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.</p> <p><b>Users disliked the app:</b> 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><b>Users wanted the app to cover:</b> 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. (2020)/ USA	<p><b>Aim:</b> To examine the acceptability, user experience, and perceptions of the app.</p> <p><b>Setting:</b> Not reported.</p>	<p><b>Design:</b> Qualitative evaluation design.</p> <p><b>Data collection:</b> Semi-structured interviews.</p> <p><b>Data analysis:</b> Thematic analysis.</p>	Smokers who were military veterans with posttraumatic stress disorder (PTSD) (N=17), 17 males.	Stay Quit Coach	YES	<p><b>Users liked the app:</b> 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><b>Users disliked the app:</b> 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</p>

						<p>the app; 4. The app did not have enough privacy.</p> <p><b>Users wanted the app to cover:</b> 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 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.</p>	
10	Klein et al. (2019)/ Australia	<p><b>Aim:</b> To explore the feasibility, acceptability, and utility of Kick.it to assist smokers with severe mental diseases to prevent smoking relapse and quit.</p> <p><b>Setting:</b> Not reported.</p>	<p><b>Design:</b> Co-design methodology.</p> <p><b>Data collection:</b> Semi-structured interviews.</p> <p><b>Data analysis:</b> Thematic analysis.</p>	Adult smokers/ex-smokers with mental diseases (N=12), 8 males, 4 females.	Kick.it	YES	<p><b>Users liked the app:</b> 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.</p> <p><b>Users disliked the app:</b> Difficult to navigate the app because of limited knowledge and skills in technology.</p> <p><b>Users wanted the app to cover:</b> 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.</p>

11	Luna-Perejon et al. (2019)/ Spain	<b>Aim:</b> To evaluate the user experience, and more specifically the usability and the user satisfaction with the app. <b>Setting:</b> University.	<b>Design:</b> Cohort study. <b>Data collection:</b> Questionnaire and expert report. <b>Data analysis:</b> 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	<b>YES</b>	<b>Users disliked the app:</b> 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. <b>Users liked the app:</b> It was easy to use.
12	Maramis et al. (2019)/ Finland	<b>Aim:</b> To present the development of QuitIT! As well as its preliminary evaluation. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative evaluation design. <b>Data collection:</b> Interviews. <b>Data analysis:</b> 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	<b>YES</b>	<b>Uses wanted the app to cover:</b> 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.
13	Meijer et al. (2021)/ Netherlands	<b>Aim:</b> To evaluate StopCoach and to explore the experience of smokers using StopCoach. <b>Setting:</b> Blended care settings within five municipalities in The Netherlands.	<b>Design:</b> Mixed-methods design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> Framework Analysis.	Lower socio-economic status (SES) smokers (n=22); Sex ratio was not reported.	StopCoach  Sources:	<b>YES</b>	<b>Users liked the app:</b> 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. (2016)/ UK	<b>Aim:</b> 1. Assess smokers' compliance with reporting their smoking in real time and identify reasons for noncompliance; 2. Assess the app's	<b>Design:</b> An explanatory sequential, mixed-methods design. <b>Data collection:</b> Interviews. <b>Data analysis:</b> Thematic analysis.	Adult smokers (N=15), 7 females, 8 males.	Q Sense  Sources: Researchers investigated the barriers and facilitators of user engagement with	<b>YES</b>	<b>Users liked the app:</b> 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.

		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. <b>Setting:</b> Not reported.			the app through mixed-methods designs and learn about its support delivery system under natural conditions		<b>Users wanted the app to cover:</b> 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. (2014)/ Denmark	<b>Aim:</b> To explore how participants, smokers and ex-smokers, interacted with the different content types and sources of Quitty. <b>Setting:</b> University.	<b>Design:</b> Qualitative exploratory design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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	<b>YES</b>	<b>Users wanted the app:</b> 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. <b>Users disliked the app:</b> 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. (2015a)/ Denmark	<b>Aim:</b> To discuss participants’ experience with the app and the role it played in their smoking cessation. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative descriptive design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> Not reported.	Adult smokers or recently quit but want to stay quit (N=13), 4 males and 9 females.	QuittyLink  Sources: Researchers designed the app based on previous studies on health behaviour change	<b>YES</b>	<b>Users liked the app:</b> 1. Was easy to use; 2. Users were interested in the 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;

					and smoking cessation, and the review of existing apps		6. The “resisted” function was useful in keeping their motivation high.
17	Paay et al. (2015b)/ Denmark	<b>Aim:</b> To gain smokers’ and ex-smokers’ attitudes towards quitting, and their ideas about how interactive technology might be used to help them quit. <b>Setting:</b> Not reported.	<b>Design:</b> An empirical investigation. <b>Data collection:</b> Focus group and design workshops. <b>Data analysis:</b> 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	<b>NO (A commercial app)</b>	<b>Users wanted the app:</b> 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. (2015c)/ Denmark	<b>Aim:</b> To explore how smokers responded to entering data about their smoking habits and then receive personal counselling advice. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative evaluation design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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	<b>YES</b>	<b>Users liked the app:</b> 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. <b>Users wanted the app:</b> 1. They can choose the timeframe of the graphs 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. (2019)/ Australia Australian and New Zealand Clinical Trials Registry ACTRN12616001550493	<b>Aim:</b> To assess the feasibility and acceptability and explore the effectiveness of a novel mHealth app to assist Aboriginal people to quit smoking. <b>Setting:</b> Community.	<b>Design:</b> A pilot randomised controlled trial (RCT) plus process evaluation. <b>Data collection:</b> A questionnaire and semi-structured interviews. <b>Data analysis</b> (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.	<b>YES</b>	<b>Users liked the app:</b> 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. <b>Users wanted the app:</b> 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. (2020)/ Romania	<b>Aim:</b> To explore the views of postpartum women on the two components of the Stay Quit Together postpartum smoking relapse prevention intervention – the iCoach mobile application and the text messages. <b>Setting:</b> Obstetrics and gynaecology clinic.	<b>Design:</b> Qualitative exploratory design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> Thematic analysis.	Women who just gave birth, have tried quitting before or during pregnancy (N=12).	iCoach  Sources: N/A	<b>YES</b>	<b>Users liked the app:</b> The panic advice and daily advice were useful. <b>Users disliked the app:</b> 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. (2017)/ Australia	<b>Aim:</b> To examine what influenced people to engage or disengage with the app, and how the app was deployed in quit attempts. <b>Setting:</b> Not reported.	<b>Design:</b> A qualitative exploratory design. <b>Data collection:</b> interviews. <b>Data analysis:</b> 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	<b>YES</b>	<b>Users liked the app:</b> 1. Had authentic and contextualised stories; 2. Stories had specific advice that was contextualised. <b>Users wanted the app:</b> 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. (2018)/ Canada	<b>Aim:</b> 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. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative case study. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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	<b>YES</b>	<b>Users liked the app:</b> 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.  <b>Users disliked the app:</b> 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.
23	Struik et al. (2019)/ Canada	<b>Aim:</b> 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	<b>Design:</b> Qualitative case study design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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	<b>YES</b>	<b>Users liked the app:</b> 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. <b>Users disliked the app:</b> 1. The app was too dark; 2. Had so many subpages which led to

		the influence of gender. <b>Setting:</b> Not reported.					“hidden” functions they were unaware of; 3. Some app functions were based on the quit date, which sometimes led to inaccurate statistics.
24	Schick et al. (2018)/ UK	<b>Aim:</b> To evaluate the app as a potential smoking cessation aid and explore user experience and technological requirements and security of the data flow. <b>Setting:</b> NHS Fife GP practice.	<b>Design:</b> Pre- and post-quit two-phase design. <b>Data collection:</b> Two face-to-face interviews, and one telephone interview. <b>Data analysis:</b> Not reported.	Adult smokers who are interested in smoking cessation (N=8), gender was not reported.	MapMysmoke  Sources: N/A	<b>YES</b>	<b>Users liked the app:</b> 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. <b>Users disliked the app:</b> 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.
25	Tudor-Sfetea et al. (2018)/ UK	<b>Aim:</b> 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. <b>Setting:</b> not reported.	<b>Design:</b> A qualitative short-term longitudinal study. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> Thematic analysis.	Adult smokers who are intended to quit (N=29), 25 males and 4 females.	Quit Genius/ NHS Smokefree  Sources: N/A	<b>NO (Downloaded from App Stores)</b>	<b>Users liked the app:</b> 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 “context behaviour therapy” method contributed to their intrinsic motivation to quit. <b>Users disliked the app:</b> 1. The 'lapse' function; 2. Lacking interactivity caused boredom and a decreased desire to use the app; 3. Lacking human contact from a physician. <b>Users liked the app:</b> 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.

							<b>Users wanted the app:</b> 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.
26	Villardaga et al. (2016) / USA	<b>Aim:</b> To evaluate user experience of the app amongst people with serious mental illness. <b>Setting:</b> A community mental health clinic.	<b>Design:</b> Qualitative evaluation design. <b>Data collection:</b> Questionnaire, Semi-structured interviews, Think aloud procedure, Daily diary. <b>Data analysis:</b> Affinity diagram, a grounded field theory approach.	Adult smokers who take psychiatric medication as prescribed (N=5), 5 males.	Quitpal  Sources: The app design was based on US Clinical Practice Guidelines for smoking cessation	<b>YES</b>	<b>Users disliked the app:</b> 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. <b>Users wanted the app:</b> 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.
27	Villardaga et al. (2019)/ USA	<b>Aim:</b> 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 were similar or different. <b>Setting:</b> Mental health clinic.	<b>Design:</b> Case studies. <b>Data collection:</b> System usability scale, UX interviews and background analytics. <b>Data analysis:</b> Thematic analysis.	Adult smokers with serious mental health diseases, who have an intention to quit (N=7), 4 females and 3 males.	Learn to Quit/ QuitGuide  Sources: LTQ was designed based on Acceptance and Commitment Therapy.  QG was designed based on US Clinical Practice Guidelines for smoking cessation	<b>YES</b>	<b>Users liked the app:</b> 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. <b>Users disliked the app:</b> 1. QuitGuide was not intuitive and was difficult to access app functions; 2. QuitGuide had a 'serious' look and feel. <b>Users wanted the app:</b> 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.

28	Wu et al. (2017)/ UK	<p><b>Aim:</b> 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.</p> <p><b>Setting:</b> Stop-smoking clinics and pregnancy-specific forums.</p>	<p><b>Design:</b> Qualitative exploratory design.</p> <p><b>Data collection:</b> Interviews.</p> <p><b>Data analysis:</b> Thematic analysis.</p>	Pregnant smokers (N=10), 10 females.	SmokeFree Baby	YES	<p><b>Users wanted the app:</b> 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.</p> <p><b>Users liked the app:</b> 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.</p>
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Table 3: Details of included papers

### 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 5 (a) and Table 5 (b).

High-Level Theme 1: App Functions

High-Level Theme 2: App Characteristics

No./Author (Year)	Education	Tracking	Social Support	Compensation	Distraction	Reminding	Simplification	Personalisation	Diverse output forms	Interactivity	Privacy and Security
1. Armin et al. (2017)		√		√					√		
2. Baskerville et al. (2018a)		√	√	√	√			√			
3. Bendotti et al. (2022)	√	√	√		√	√	√	√		√	
4. El-Hilly et al. (2016)	√	√	√				√	√			
5. Edwards et al. (2018)	√			√	√			√		√	
6. Fulton et al. (2018)							√		√		
7. Gowarty et al. (2020)	√	√	√	√	√	√				√	
8. Gowarty et al. (2021)		√	√	√		√	√				
9. Herbst et al. (2020)	√	√	√	√	√	√	√		√	√	
10. Klein et al. (2019)		√	√				√	√			√

11. Luna-Perejon et al. (2019)	√			√	√	√	√			
12. Maramis et al. (2019)		√					√	√		
13. Meijer et al. (2021)	√	√					√			
14. Naughton et al. (2016)		√	√			√		√	√	√
15. Paay et al. (2014)	√	√	√			√		√		√
16. Paay et al. (2015a)		√	√	√			√	√		
17. Paay et al. (2015b)	√	√	√	√	√	√		√		√
18. Paay et al. (2015c)		√	√			√	√	√		
19. Peiris et al. (2019)			√		√	√	√	√		√
20. Rusu et al. (2020)	√						√		√	√
21. Smith et al. (2017)	√		√		√				√	√
22. Struik et al. (2018)		√	√	√	√	√		√		√

23. Struik et al. (2019)	√	√	√	√			√	√			
24. Schick et al. (2018)		√	√			√					
25. Tudor-Sfetea et al. (2018)	√	√	√		√	√	√	√	√	√	
26. Vilardaga et al. (2016)		√		√		√	√	√			√
27. Vilardaga et al. (2019)		√			√		√				√
28. Wu et al. (2017)	√		√		√		√	√	√	√	
<b>Total</b>	<b>14</b>	<b>21</b>	<b>19</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>18</b>	<b>17</b>	<b>7</b>	<b>14</b>	<b>4</b>

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

### 3.2.1 App functions

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#### **Subtheme 1: Education**

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"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)" (Tudor-Sfetea et al., 2018)

"Maybe it could give you an explanation of how your health is improving." (Edwards et al., 2018)

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#### **Subtheme 2: Tracking**

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"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." (Herbst et al., 2020)

"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." (Paay et al., 2015c)

"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!'" (Paay et al., 2014)

"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" (Struik et al., 2018)

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#### **Subtheme 3: Social support**

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"Don't want to share progress on social media in case you fail." (Tudor-Sfetea et al., 2018)

"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..." (Gowarty et al., 2020)

"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" (Wu et al., 2017)

"You'd have each other to lean on and to express what you're feeling" (Peiris et al., 2019)

"It's like relating your experiences to theirs and trying to find what you can do about it" (Smith et al., 2017)

"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?" (Paay et al., 2015b)

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#### **Subtheme 4: Compensation**

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"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." (Herbst et al., 2020)

"My reward should be bigger than how delicious I think it is to smoke." (Paay et al., 2015b)

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“Cigarettes are rewarding to us, physically and psychologically, they’re rewarding. . . . Give me the reward, man! . . .I quit [smoking]!” (Armin et al., 2017)

“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” (Struik et al., 2019)

“After a week it would be good to tot up how much money you have saved.” (Edwards et al., 2018)

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#### **Subtheme 5: Distraction**

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“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.” (Herbst et al., 2020)

“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.” (Tudor-Sfetea et al., 2018)

“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.” (Edwards et al., 2018)

“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...” (Gowarty et al., 2020)

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#### **Subtheme 6: Reminding**

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“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.” (Herbst et al., 2020)

“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.’ ...” (Peiris et al., 2019)

“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.” (Tudor-Sfetea et al., 2018)

“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’” (Paay et al., 2015b)

“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.” (Paay et al., 2014)

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**Table 5 (a): Illustrative quotes (examples) from included studies to support the App Functions theme**

### 3.2.1.1 Education

Education meant providing information to smokers, not only showing them what they could gain and lose through smoking cessation (Tudor-Sfetea et al., 2018) but also teaching them to cope with negative emotions such as anxiety as well as urges and cravings to smoke (Wu et al., 2017, Rusu et al., 2020, Herbst et al., 2020, Luna-Perejon et al., 2019).

Participants wanted apps to provide more information (Gowarty et al., 2020, Meijer et al., 2021, Paay et al., 2015b) going beyond what they already knew (Paay et al., 2015b, El-Hilly et al., 2016). Users preferred to receive positive information (Luna-Perejon et al., 2019, Schick et al., 2018, Paay et al., 2014, Edwards et al., 2018, Struik et al., 2019) from experts (Smith et al., 2017, Paay et al., 2014) or other smokers in a similar situation (Wu et al., 2017). Educational information should be tailored to individual needs (Paay et al., 2015b), with content updated regularly to increase engagement with a smoking cessation app (Wu et al., 2017, Paay et al., 2015b, El-Hilly et al., 2016).

### 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 (Paay et al., 2014, El-Hilly et al., 2016, Armin et al., 2017, Herbst et al., 2020, Gowarty et al., 2021, Bendotti et al., 2022), but also make users more self-aware of their smoking patterns and psychological triggers to smoke (Bendotti et al., 2022, Klein et al., 2019, Struik et al., 2019, Vilardaga et al., 2019, Schick et al., 2018, Gowarty et al., 2020, Tudor-Sfetea et al., 2018, Meijer et al., 2021). Some apps even can show the location where users smoked using a map (Schick et al., 2018, Naughton et al., 2016). The challenge of tracking is that users sometimes struggled to report smoking in real time (Naughton et al., 2016).

### 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 (Paay et al., 2014, Baskerville et al.,

2018a, Peiris et al., 2019, Tudor-Sfetea et al., 2018, Smith et al., 2017, Bendotti et al., 2022). In a study with people with mental conditions, through the social support function, the app had the potential to decrease stigma, sense of loneliness (Klein et al., 2019). Smith et al. (2017) 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. (2022) 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 (Wu et al., 2017, Gowarty et al., 2021, El-Hilly et al., 2016, Struik et al., 2018).

#### 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 (Vilardaga et al., 2016, Paay et al., 2015b, Armin et al., 2017, Edwards et al., 2018, Baskerville et al., 2018a, Struik et al., 2018, Struik et al., 2019, Luna-Perejon et al., 2019, Herbst et al., 2020, Gowarty et al., 2020, Gowarty et al., 2021). For example, virtual rewards, such as imagery or recordings of walking in fresh air and listening to birds singing, was appreciated by some users (Armin et al., 2017, Luna-Perejon et al., 2019), while other participants wanted psychological rewards such as digital badges to increase the quitting motivation (Gowarty et al., 2020).

#### 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 (Paay et al., 2015b, Smith et al., 2017, Struik et al., 2018, Herbst et al., 2020, Peiris et al., 2019, Vilardaga et al., 2019, Edwards et al., 2018, Tudor-Sfetea et al., 2018, Bendotti et al., 2022) or suggested users perform physical exercise (Luna-Perejon et al., 2019) or have

something to eat or drink (Baskerville et al., 2018a) to distract them from smoking or craving events. For instance, in Struik et al. (2018), young smokers preferred games to YouTube videos, as games kept their hands busy to distract them from smoking. Similarly, participants in Wu et al. (2017) 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 (Paay et al., 2014, Paay et al., 2015b, Paay et al., 2015c, Vilardaga et al., 2016, Naughton et al., 2016, Tudor-Sfetea et al., 2018, Schick et al., 2018, Struik et al., 2018, Peiris et al., 2019, Luna-Perejon et al., 2019, Gowarty et al., 2020, Gowarty et al., 2021, Herbst et al., 2020, Bendotti et al., 2022).

Although some found reminders or notifications annoying, especially at inconvenient times (Paay et al., 2014, Vilardaga et al., 2016), most users found them useful motivational tools (Paay et al., 2014, Paay et al., 2015c, Vilardaga et al., 2016, Struik et al., 2018, Tudor-Sfetea et al., 2018, Herbst et al., 2020, Gowarty et al., 2021).

Notably, users seemed to prefer to receive reminders from a real person, not a machine, as this was more motivating to stop smoking (Paay et al., 2015b, Paay et al., 2014, Paay et al., 2015c). 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 (Bendotti et al., 2022, Schick et al., 2018, Paay et al., 2015b, Peiris et al., 2019, Luna-Perejon et al., 2019, Gowarty et al., 2020).

### 3.2.2 App characteristics

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#### **Subtheme 1: Simplification**

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“Easy and fast. It takes a quarter of a second to open and then you just press save and ‘bang’, you are done” (Paay et al., 2015c)

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“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”(Struik et al., 2019)

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**Subtheme 2: Personalisation**

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“It means a lot that it was written specifically to me, what I should do, and not what others should do” (Paay et al., 2015c)

“Being personalized is definitely important.” (Edwards et al., 2018)

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**Subtheme 3: Diverse content formats**

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“There is too much text. There should be more images” (Rusu et al., 2020)

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**Subtheme 4: Interactivity**

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“It just needs to be made more interactive.” (Tudor-Sfetea et al., 2018)

“It has to be interactive to work.” (Edwards et al., 2018)

“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” (Wu et al., 2017)

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**Subtheme 5: Privacy and Security**

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“The safety of the program - the personal data, so nobody can access it” (Rusu et al., 2020)

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**Table 5 (b): Illustrative quotes (examples) from included studies to explain the theme App Characteristics**

3.2.2.1 Simplification

Simplification meant the smoking cessation apps should be quick and easy to use (Paay et al., 2015a, Paay et al., 2015c, El-Hilly et al., 2016, Vilardaga et al., 2016, Wu et al., 2017, Fulton et al., 2018, Tudor-Sfetea et al., 2018, Luna-Perejon et al., 2019, Maramis et al., 2019, Peiris et al., 2019, Klein et al., 2019, Vilardaga et al., 2019, Struik et al., 2019, Herbst et al., 2020, Rusu et al., 2020, Gowarty et al., 2021, Bendotti et al., 2022, Meijer et al., 2021). If an app was not intuitive and easy to follow, users needed further training or guidance on how to use it (Tudor-Sfetea et

al., 2018, Klein et al., 2019, Peiris et al., 2019). Vilardaga et al. (2019) 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. (2019), 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 (Paay et al., 2015a, Paay et al., 2015c, Vilardaga et al., 2016, Naughton et al., 2016, Wu et al., 2017, Edwards et al., 2018, Tudor-Sfetea et al., 2018, Klein et al., 2019, Maramis et al., 2019, Peiris et al., 2019, Bendotti et al., 2022), tailored quitting dates and plans (Edwards et al., 2018), tailored educational information (Struik et al., 2018), personalised rewards (El-Hilly et al., 2016), or tailored tracking modes (Baskerville et al., 2018a). Bendotti et al. (2022) 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 (Naughton et al., 2016, Armin et al., 2017, Wu et al., 2017, Tudor-Sfetea et al., 2018, Fulton et al., 2018, Herbst et al., 2020, Rusu et al., 2020). 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 (Armin et al., 2017).

#### 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 (Paay et al., 2014, Paay et al., 2015b, Vilardaga et al., 2016, Vilardaga et al., 2019, Smith et al., 2017, Wu et al., 2017, Tudor-Sfetea et al., 2018, Edwards et al., 2018, Struik et al., 2018, Struik et al., 2019, Peiris et al., 2019, Herbst et al., 2020, Gowarty et al., 2020, Bendotti et al., 2022).

### 3.2.2.5 Privacy and Security

Privacy and security when using a smoking cessation app was a concern in some studies (Naughton et al., 2016, Smith et al., 2017, Klein et al., 2019, Rusu et al., 2020). Users were worried about the safety of their data (Rusu et al., 2020), or valued anonymity when using the app to quit smoking as this made them feel safe (Smith et al., 2017). Interestingly, in Naughton et al. (2016), 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. (2017) 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. (2019) 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. (2016) 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 (Dennison et al., 2013).

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 (Hussain et al., 2012) and Lopez-Fernandez et al. (2014) 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 (Cobos-Campos et al., 2020). 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 (WHO, 2023a). 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 (Sharma et al., 2022, Martínez-Pérez et al., 2013). 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 (WHO, 2011).

#### 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 participant's age cannot be found (Peiris et al., 2019). 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 (Dixon-Woods et al., 2007, Reynolds et al., 2011), 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.

### 4.3 Conclusion

As stated in section 4.1, the overall aim of this systematic review throughout the thesis was to identify contexts and mechanisms for using smoking cessation apps. This conclusion section presents a synthesis of evidence on these contexts and mechanisms based on the findings of this qualitative systematic review. The review evaluated the current evidence on user needs and user experience of smoking cessation apps by exploring common app features and characteristics, which acted as contexts and mechanisms in smoking cessation apps.

In this study, user needs are important contexts for the successful implementation of smoking cessation apps. Four contexts were identified based on the findings of this review. The first context was that smokers wanted to seek positive feedback to

strengthen their motivation and self-efficacy. The review findings showed that smokers were more likely to be motivated by positive changes due to smoking cessation, such as the achievements of quitting smoking and the rewards of smoking cessation. Positive feedback gave smokers a sense of achievement and made them more confident in keeping abstinent. In addition, the educational content within these apps also played a crucial role. By providing detailed information about the health risks associated with smoking and the benefits of cessation, smokers will be more motivated to stop smoking.

The second context was that smokers wanted to seek social support through apps. The findings of this review indicated that most smokers liked the social features within apps. Engaging in the social platforms within apps enabled them to communicate with like-minded people, which allowed them to receive understanding and support from other quitting peers. The social features had the potential to decrease social stigma linked with smoking and a sense of loneliness because other app users were quitting buddies who shared similar barriers and experiences with them, so it is easier for cutting peers to empathise with each other compared with non-smokers.

The third context was smokers seek support from apps to help them prevent relapse. The review findings showed that some smoking cessation apps provided detailed tracking of craving patterns, including location, time, intensity, and reasons. This tracking feature, prevalent in most apps, allowed users to clearly understand their high-risk situations, aiding in better management of cravings. Furthermore, the distraction feature provided smokers with alternatives to smoking, such as mini-games within apps. The distraction strategy can potentially engage smokers in different activities, reducing the likelihood of giving in to cravings. Furthermore, the education features also equipped smokers with the knowledge to cope with withdrawal symptoms, including cravings.

The last context identified was that smokers wanted smoking cessation apps to be easy to use, interactive, personalised, and respectful of privacy. The review findings showed that ease of use is crucial for the effectiveness of smoking cessation apps. Users are more likely to continue using an app and benefit from it if they find it

straightforward and intuitive. This ease of use contributed significantly to the overall success and high user engagement level. In addition, users preferred multiple media formats, such as audio and video formats, to make the user experience engaging and enjoyable. Regarding potential improvements, some users expressed a desire for additional features such as background music or imagery, which could create a more soothing and relaxing environment, aiding in the smoking cessation process by providing a more positive user experience. Personalisation was a key factor in improving user experience in smoking cessation apps. It allowed users to set individual goals and receive tailored support that better met specific user needs. Personalisation enhanced user engagement and app features that, combined with the personalisation characteristic, were more welcomed by smokers. Privacy and security concerns were significant factors influencing user experience with smoking cessation apps. Smokers were more likely to engage with an app if they were confident that their personal data was being handled securely and their privacy was respected. Ensuring robust privacy measures can enhance trust and potentially increase user engagement.

In the next chapter, I will present the second systematic review, which complemented this qualitative review and aimed to identify different outcomes of using smoking cessation apps.

## CHAPTER FIVE: A systematic review of outcomes of using mHealth interventions in smoking cessation

### 5.1 Introduction

The previous chapter covers the first systematic review exploring the contexts and mechanisms of smoking cessation apps in aiding smokers in quitting. This chapter presents the second systematic review as one of the steps of formulating IPTs. It starts with the background of mHealth interventions in smoking cessation, including existing research and their limitations, the most updated consensus on measuring smoking cessation outcomes, and the research question of this review. Then, the methods and findings were presented. Lastly, an evidence synthesis was given to indicate how the findings of the two systematic reviews could provide complementary insights to formulate IPTs. Complementing the first review, the findings of this second systematic review reveal how the outcomes of using smoking cessation apps were influenced by the interplay of contextual factors and activated mechanisms, therefore leading to the success or failure of mHealth interventions.

### 5.2 Background

mHealth interventions offer an innovative and tailored approach to help smokers stop smoking. Two existing systematic reviews have examined the effectiveness of different mHealth interventions in smoking cessation (Do et al., 2018, Whittaker et al., 2019). Do et al. (2018) examined the effectiveness of four types of eHealth interventions, including mHealth interventions, Internet-based interventions, computer-assisted interventions, and other electronic-assisted interventions. In addition, Whittaker et al. (2019) focused on examining the long-term effectiveness of SMS and app-based interventions in smoking cessation, with the follow-up period longer than six months. Do et al. (2018) found that mHealth interventions were significantly more effective than non-active control groups, such as smoking cessation brochures only. However, only the beneficial effects of these interventions for follow-ups of less than six months were found in this review. Whittaker et al. (2019) found that SMS interventions were effective but did not find evidence that smoking cessation apps increased quit rates in the long term (follow-up more than six months).

Although both studies explored the effectiveness of mHealth interventions, neither of them identified the long-term effectiveness of mHealth interventions in smoking cessation. However, smoking cessation requires prolonged persistence to overcome both physiological and psychological dependencies to change the smoking habit (Livingstone-Banks et al., 2019, Glass, 1991). Thus, when evaluating smoking cessation interventions, it is vital not only to focus on how they help smokers alter their smoking behaviour in the short term but also to consider how to increase their long-term effectiveness (Marlatt and Gordon, 1985). This helps to determine how smokers maintain abstinence over an extended period while reducing the risk of relapse. Therefore, this study focused on the long-term effectiveness of mHealth interventions in smoking cessation.

The most updated consensus on measuring smoking cessation outcomes indicates that 6- or 12-month prolonged abstinence rate, 7-day point abstinence (PAR), and 6-month continuous abstinence rate (CAR) are important self-reported outcome measures (West, 2005, Cheung et al., 2017). In addition, the preferred follow-up periods for measuring these outcomes are 6 or 12 months (Cheung et al., 2017). Before presenting this systematic review, it is crucial to explain the three types of self-reported abstinence commonly used in smoking cessation studies. CAR refers to no smoking behaviour from the initiation of smoking cessation up to the follow-up assessment (Cheung et al., 2017). Point abstinence means no smoking occurred during a specific period leading up to the assessment (Cheung et al., 2017). For instance, 7-day PAR indicates that the smokers did not smoke for seven consecutive days preceding the assessment. Finally, prolonged abstinence differs from CAR since the quit date. It is defined as a sustained non-smoking status where a brief relapse does not count as a failure (Pierce and Gilpin, 2003).

Since mHealth interventions for smoking cessation might share similar components, such as providing educational information, tracking smoking cessation progress, offering social support, etc., mHealth interventions other than apps could lead to similar changes in smokers. In this review, I decided to cover all mHealth interventions related to smoking cessation, not just limited to apps. Firstly, this will facilitate a comprehensive understanding of the changes that happen to smokers

when engaging with different mHealth interventions. In addition, by comparing the effectiveness of different health interventions, factors that lead to the success or failure of these interventions could be examined.

Therefore, the aim of this review was to synthesise existing evidence to identify the outcomes of using mHealth interventions in smoking cessation. The review question is:

*"What are the long-term outcomes caused by the use of mHealth interventions in smoking cessation?"*

## 5.3 Methods

### 5.3.1 Outcome of interest

- Long-term outcomes of using mHealth interventions in smoking cessation (In this review, long-term outcome was defined as follow-up longer than six months)

### 5.3.2 Search strategy

The PICO framework was adopted to develop the search strategy (Scells et al., 2017). Search terms were entered into seven databases: CINAHL (via EBSCOHost), EMBASE (via Ovid), MEDLINE (via Ovid), PsycINFO (via Ovid), Cochrane Database of Systematic Reviews (CDSR), ACM Digital Library, and IEEE Xplore to identify eligible studies. Since the ACM Digital Library and IEEE Xplore databases are highly likely to contain articles related to mHealth interventions, to make the search results more relevant and manageable, I searched for papers in these two databases where the keywords appeared in the abstracts.

This review included only RCTs and used "RCT" as one of the search terms for the following reasons. Firstly, RCTs are recognised as the "gold standard" for evaluating intervention effectiveness, providing stronger support for causal relationships (Evans, 2003). Secondly, this review aims to compare the effectiveness of various mHealth interventions and other active or nonactive interventions. Using "RCT" as a

search term, without predetermining the comparison groups, allows for a more extensive and comprehensive scope of studies.

Except for the study type, other search terms were mapped to suggested MeSH subject terms and exploded to retrieve all references indexed to these MeSH terms and their child or narrower terms. No limit on publication year was applied. The search terms of this review are attached in Appendix 12.

### 5.3.3 Selection criteria

Table 5.1 presents the inclusion and exclusion criteria.

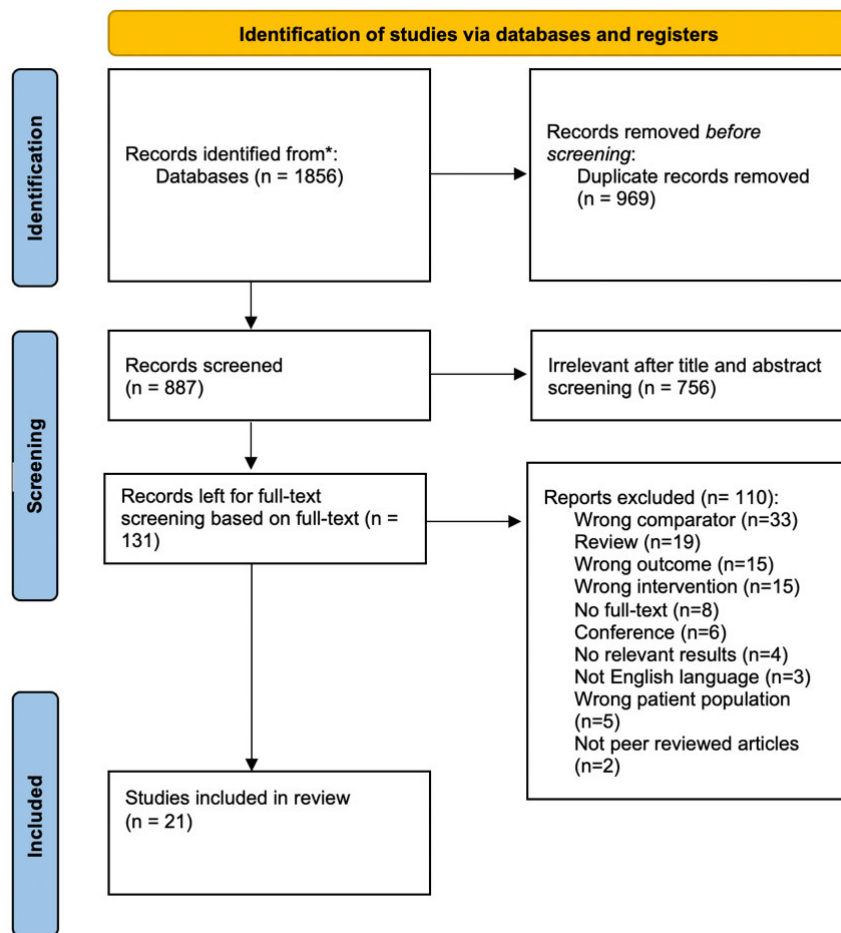
	<b>Inclusion criteria</b>	<b>Exclusion criteria</b>
<b>Population</b>	Adult smokers	Smokeless or adolescent smokers
<b>Intervention</b>	Contain any type of mHealth interventions of smoking cessation: mobile apps, quitlines, SMS etc.	No mHealth interventions
<b>Comparison</b>	Usual care or traditional interventions	N/A
<b>Outcome</b>	Follow-up period longer than 6 months	Follow up period less than 6 months

Table 5.1 Inclusion and exclusion criteria for the 2<sup>nd</sup> systematic review

### 5.3.4 Screening

Covidence (Covidence, 2021) was used to screen titles, abstracts and full texts. To ensure rigour and avoid selection bias, another PhD candidate (XL) and I separately screened titles and abstracts. Conflicts were discussed on meetings. Exclusion reasons were noted in Covidence in the full-text screening process. Conflicts regarding eligibility or exclusion reasons were discussed on meetings, with supervisors providing advice. This systematic review followed the Preferred Reporting Items for Systematic PRISMA statement (Page et al., 2021) (Figure 5.1).

Figure 5.1: PRISMA Flowchart of the 2<sup>nd</sup> systematic review



### 5.3.5 Data extraction

The data extraction form (Table 5.3 in section 5.4) was designed beforehand and piloted on five included studies. Another PhD student (XL) and I independently used this data extraction form to extract pertinent data from the five selected papers and compare the extracted information. The remaining data extraction was conducted by me.

### 5.3.6 Quality appraisal

Critical Appraisal Skills Programme (CASP) checklist for RCTs was used to appraisal the quality of included papers (CASP, 2020). The CASP assessment tool consists of four sections (A, B, C, D) with a total of 11 questions, each question offering three options: "Yes," "No," and "Can't tell." Section A primarily assesses the validity of the study design. Section B evaluates whether the research methodology is rigorous. Section C checks whether the reporting of the results is comprehensive.

Section D discusses the applicability of the research findings. Although the CASP assessment tool does not recommend a fixed scoring system because it was initially designed for educational purposes, however, it still provides a structured method to evaluate the quality of research. To facilitate the interpretation of appraisal results and make the results more straightforward, I considered using quantitative evaluation criteria based on the CASP checklist (Zwakman et al., 2018, Silies et al., 2021). After consultation with the supervision team, it was agreed that if 9-11 questions were answered with "Yes", the study was judged as high quality. If 6-8 questions were answered with "Yes", it was judged medium quality. If fewer than 6 questions received a "Yes", it was considered as low quality.

To ensure the robustness of the quality appraisal, five of the papers were independently appraised by me and another PhD candidate (XL) and any disagreements were resolved through discussion. The remaining papers were appraised by me, and any issues were discussed with the PhD supervisors. No paper was excluded from this appraisal process. The quality appraisal results are presented in Table 5.3.

### 5.3.7 Data analysis

Narrative synthesis (Popay et al., 2006) was employed to systematically summarise the findings of the included studies, to gain a comprehensive understanding of what outcomes are produced through the use of mHealth interventions in smoking cessation. Narrative synthesis, rather than a meta-analysis, was conducted since this approach allows for a detailed explanation of the outcomes of using mHealth interventions by exploring the reasons for the success or failure of long-term effectiveness (Popay et al., 2006). Data analysis results were summarised according to the outcomes of interests of this review (Section 5.2.1).

## 5.4 Result

### 5.4.1 Study characteristics

#### 5.4.1.1 Participants

Among the included studies, most participants were general adult smokers (n=15), meaning they have no specific diseases or conditions, except one study focused on adult hospitalised smokers (Harrington et al., 2016). Five studies (n=5) centred on smoking parents or smokers who were about to become parents (Abdullah et al., 2005, Cummins et al., 2016, Schuck et al., 2014, Xia et al., 2020, Yu et al., 2017). One study (n=1) focused on young smokers aged between 19 and 29 years old (Baskerville et al., 2018b). The demographic characteristics of participants, such as mean age, gender distribution and number of cigarettes per day, are presented in Table 5.3.

#### *5.4.1.2 Country of studies*

The included studies (n=21) were published between 2005 and 2022 and took place in different countries (regions). Four studies were conducted in Hong Kong (Special administrative region of China); three each from the US and Netherlands; two were from Norway; and one each from the Mainland of China, Thailand, Canada, Spain, Germany, the UK, France, Ireland, and Denmark.

#### *5.4.1.3 Type of studies*

In most instances, the included studies were two-arm RCTs (n=15), with one arm containing mHealth intervention and the other arm being a non-mHealth control condition. Five studies (n=5) were three-arm RCTs (Chan et al., 2015, O'Connor et al., 2020, Smit et al., 2016, Xia et al., 2020, Yu et al., 2017). One studies were four-arm RCTs (Skov-Ettrup et al., 2016). In the three-arm and four-arm RCTs where at least one intervention group is a mHealth intervention, the effectiveness of different interventions was compared with each other and the control group. The conditions in all intervention and control groups are presented in Table 5.3.

#### *5.4.1.4 Intervention groups and control groups*

The mHealth interventions for smoking cessation used in the included studies varied. Online programmes were the most frequently used intervention (n=7) (Brendryen et al., 2008, Brendryen and Kraft, 2008, Haug et al., 2011, McDonnell et al., 2011, Smit et al., 2012, Harrington et al., 2016, Smit et al., 2016). Seven studies used message

support (via SMS, email, or chatbox) (Naughton et al., 2014, Chan et al., 2015, Skov-Ettrup et al., 2016, Yu et al., 2017, Nguyen Thanh et al., 2019, Wang et al., 2019, Xia et al., 2020). Four studies (n=5) used proactive or reactive telephone counselling (Abdullah et al., 2005, Schuck et al., 2014, Chan et al., 2015, Cummins et al., 2016, Skov-Ettrup et al., 2016). Four studies (n=4) used a mobile app as the intervention (Baskerville et al., 2018b, Carrasco-Hernandez et al., 2020, O'Connor et al., 2020, Asayut et al., 2022). One study used a social platform to send videos to promote smoking cessation (Xia et al., 2020).

The mHealth interventions were used alone (Abdullah et al., 2005, Haug et al., 2011, Brendryen et al., 2008, Brendryen and Kraft, 2008, Harrington et al., 2016, McDonnell et al., 2011, Nguyen Thanh et al., 2019, Skov-Ettrup et al., 2016, Smit et al., 2012, Smit et al., 2016, Xia et al., 2020, Baskerville et al., 2018b) or combined with other smoking cessation interventions, such as pharmacotherapy and counselling (Asayut et al., 2022), self-help materials, psychopharmacological treatment (Carrasco-Hernandez et al., 2020), brief advice (Naughton et al., 2014, Wang et al., 2019), or acceptance and commitment therapy (O'Connor et al., 2020).

Interventions in the control groups included the use of non-digital interventions, such as self-help materials (n=11) (Abdullah et al., 2005, Brendryen and Kraft, 2008, Brendryen et al., 2008, McDonnell et al., 2011, Schuck et al., 2014, Chan et al., 2015, Cummins et al., 2016, Skov-Ettrup et al., 2016, Baskerville et al., 2018b, Nguyen Thanh et al., 2019, Xia et al., 2020), usual smoking cessation services or treatments (n=4) (Haug et al., 2011, O'Connor et al., 2020, Carrasco-Hernandez et al., 2020, Asayut et al., 2022), and brief advice from health practitioners or smoking cessation counsellors (n=4) (Naughton et al., 2014, Harrington et al., 2016, Smit et al., 2016, Wang et al., 2019). Two studies (n=2) had no intervention for the control group (Smit et al., 2012, Yu et al., 2017).

#### *5.4.1.5 Outcome measurements*

Smoking cessation outcomes were measured differently in the included studies (Table 5.2). Regarding the follow-up period, since one inclusion criteria includes assessment of outcomes six months or over, all included studies provided follow-up

at six months or longer. Most studies used self-reported PAR to assess abstinence rate (AR): 24-hour PAR (n=3) (Smit et al., 2012, Abdullah et al., 2005, Smit et al., 2016), 7-day PAR (n=11) (Abdullah et al., 2005, Chan et al., 2015, Haug et al., 2011, Nguyen Thanh et al., 2019, Smit et al., 2012, Wang et al., 2019, Schuck et al., 2014, Baskerville et al., 2018b, McDonnell et al., 2011, Smit et al., 2016, Xia et al., 2020), or 30-day PAR (n=4) (Harrington et al., 2016, McDonnell et al., 2011, Baskerville et al., 2018b, Skov-Ettrup et al., 2016).

Six studies (n=6) assessed CAR (Asayut et al., 2022, Baskerville et al., 2018b, Smit et al., 2016, Skov-Ettrup et al., 2016, Abdullah et al., 2005, Naughton et al., 2014). Three studies (n=3) assessed 3-month or 6-month prolonged abstinence at follow-ups (Naughton et al., 2014, Schuck et al., 2014, Smit et al., 2016). Two studies (n=2) assessed repeated 7-day PAR at follow-ups (Brendryen and Kraft, 2008, Brendryen et al., 2008), which means participants achieved 7-day PAR at all follow-ups. However, Cummins et al. (2016) was not included in Table 5.2. Its follow-up times were two months and six months postpartum, so it was difficult to define how long the follow-up period was (since the intervention implementation date varied). Seven studies (n=7) provided biochemical verification of the abstinence state (Carrasco-Hernandez et al., 2020, O'Connor et al., 2020, Xia et al., 2020, Wang et al., 2019, Abdullah et al., 2005, Chan et al., 2015, Naughton et al., 2014) via exhaled Carbon Oxide or urine cotinine tests.

Table 5.2: Outcome measurements in included studies

	Self-reported abstinence rate							Bio-verified abstinence rate
	Point-abstinence rate			Prolonged abstinence rate			Repeated 7-day abstinence rate at all follow ups	
	24-hour (n)	7-day	30-day	Continued	3-month prolonged	6-month prolonged		
Follow up: 6-month	(Smit et al., 2012, Abdullah et al., 2005, Smit et al., 2016)	(Abdullah et al., 2005, Chan et al., 2015, Haug et al., 2011, Nguyen Thanh et al., 2019, Smit et al., 2012, Wang et al., 2019, Baskerville et al., 2018b, Smit et al., 2016, Xia et al., 2020)	(Harrington et al., 2016, Baskerville et al., 2018b, Skov-Ettrup et al., 2016)	(Asayut et al., 2022, Baskerville et al., 2018b, Smit et al., 2016, Abdullah et al., 2005, Naughton et al., 2014, Skov-Ettrup et al., 2016)	(Naughton et al., 2014)	N/A	N/A	(Wang et al., 2019, Xia et al., 2020, O'Connor et al., 2020, Abdullah et al., 2005, Chan et al., 2015, Naughton et al., 2014)
Follow up: 12-month	(Smit et al., 2016)	(Schuck et al., 2014, Chan et al., 2015, McDonnell et al., 2011, Nguyen Thanh et al., 2019, Smit et al., 2016)	(McDonnell et al., 2011, Skov-Ettrup et al., 2016)	(Skov-Ettrup et al., 2016)	N/A	(Schuck et al., 2014, Smit et al., 2016)	(Brendryen and Kraft, 2008, Brendryen et al., 2008)	(Carrasco-Hernandez et al., 2020, Chan et al., 2015)

Table 5.3: Data extraction of included studies in 2<sup>nd</sup> systematic review

<b>a. Author (Year)</b> <b>b. Country</b> <b>c. No.</b>	<b>a. Type of study</b> <b>b. Sample size</b> <b>c. Quality</b> <b>d. Aims</b>	<b>a. Targeted population</b> <b>b. Mean age</b> <b>c. Gender</b> <b>d. Number of cigarettes per day</b>	<b>Mode and details of intervention (Intervention group - IG)</b>	<b>Mode and details of control (Control group - CG)</b>	<b>Main findings (Statistical)</b>
<b>a. Abdullah et al. (2005)</b>  <b>b. Hong Kong (China)</b>  <b>c. 1</b>	<b>a. Two-arm RCT</b>  <b>b. 952 (467 in intervention group and 485 in control group)</b>  <b>c. high</b>  <b>d. To examine the effectiveness of telephone counselling on helping parents to quit smoking</b>	<b>a. Smoking parents of young children</b>  <b>b. N/A</b>  <b>c. 84% males, 16% females</b>  <b>d. Mean= 14.5 (SD=8.9)</b>	<b>Three-session telephone-based smoking cessation counselling plus self-help materials</b>	<b>Only self-help materials</b>	<b>ITT: At 6-month follow up, the self-reported 7-day PAR was larger in the intervention group (15.3%; 68/444) than the control group (7.4%; 34/459) (P &lt; 0.001), OR=2.1 (95% CI:1.4-3.4)</b>
<b>a. Asayut et al. (2022)</b>  <b>b. Thailand</b>  <b>c.2</b>	<b>a. A prospective, multicenter RCT</b>  <b>b. 156 (intervention group 78 and control group 78)</b>  <b>c. medium</b>  <b>d. To evaluate the effectiveness of smoking cessation services provided by community pharmacists using PharmQuit compared with standard care</b>	<b>a. Adult smokers who are ready to quit</b>  <b>b. Intervention group (IG): 33.5 (SD= 14.2); Control group (CG): 35.0 (SD=16.4)</b>  <b>c. Intervention group 91% male; Control group 92.3% male</b>	<b>PharmQuit plus usual smoking cessation services with pharmacotherapy and counselling</b>	<b>Usual smoking cessation services with pharmacotherapy and counselling</b>	<b>No significant differences found between the two groups. Participants in both groups showed an increase in AR, number of cigarettes smoked per day, exhaled CO, and adherence to the cessation programme.</b>  <b>ITT: The 7-day PAR (last visit) were not different between the groups at each follow-up visit. IG-32.1%; CG-34.6% (OR=0.89, 95% CI: 0.46-1.73, p-value=0.734)</b>  <b>CAR: Intervention group-11.5%; Control group-12.8% (OR=0.88, 95% CI: 0.34-2.32, p-value=0.807)</b>

		d. Intervention group: 11.9 (SD=6.9); Control group:12.3 (SD=8.2)			Adherence to the cessation programme was not different between groups. However, the number of visits and days adhered to the programme were higher in the IG than in the CG.
a. Baskerville et al. (2018b)  b. Canada  c. 3	a. Parallel, double-blind RCT  b. 1599 (IG 820, CG 779)  c. high  d. To determine the effectiveness of a smoking cessation app (Crush the Crave (CTC)), in comparison with an evidence-based self-help guide, On the Road to Quitting (OnRQ)	a. Young adult smokers (19-29 years old)  b. 19-23 years old: IG 49.9%, CG 48.3%  c. IG 55.1% male, CG 53% male  d. N/A	Receive CTC for 6 months	Receive self-help booklet for 6 months	ITT: CARs of 13.8% (49/354) for CTC and 15.4% (57/371) for OnRQ (OR 0.89, 95% CI 0.59-1.34, <i>P</i> =.56) for 6 months. 7-day PAR at 6 months: 33.3% in CTC and 39.1% in OnRQ, OR=0.78 (0.57-1.06), <i>p</i> value=0.11 30-day PAR at 6 months: 24.4% in CTC and 29.3% in OnRQ, OR=0.78 (0.56-1.09), <i>p</i> value=0.14 Although not statistically significant, higher cessation outcomes favoured the OnRQ condition for participants with high school education or less or for those reporting high levels of social support (64/354, 18.2% vs 35/371, 9.5%, OR 0.48, 95% CI 0.22-1.06, <i>p</i> value=0.07 Higher satisfaction and perceived helpfulness with the self-help booklet OnRQ compared with the CTC app. The participants likely perceived CTC as too complex to use as compared with a self-help booklet
a. Brendryen et al. (2008)  b. Norway  c. 4	a. Two-arm RCT  b. 290 (IG 144, CG 146)  c. high  d. To assess the 12-month effectiveness of Happy Ending (HE) and to explore the potential	a. Adult smokers who are willing to quit on a prescribed day without using nicotine replacement	HE: an intense 1-year smoking cessation programme	A 44-page self-help booklet (general smoking cessation tips, a quit calendar, a 10-day quit log, quitline	ITT: participants in the IG ( <i>n</i> = 29, 20%) reported statistically significantly higher repeated PARs than CG ( <i>n</i> = 10, 7%) (OR = 3.43, 95% CI 1.60-7.34, <i>n</i> = 290, <i>P</i> = .002).  ARs were significantly higher for the treatment condition than the control condition at 1, 3, and 6 months. At 12 months, however, the difference only reached a marginal significance level.

	effect of HE on coping planning and self-efficacy	b. IG: 39.5 (SD=11.0); CG: 39.7 (SD=10.8) c. IG: 50% male; CG: 50% male d. IG: 16.6 (SD=7.2); CG: 17.6 (SD=7.0)		information, and links to online smoking cessation resources )	HE slightly increased coping planning and self-efficacy level during the 2-week preparation phase of the programme.
a. Brendryen and Kraft (2008) b. Norway c. 5	a. Two-arm RCT b. 396 (IG 197, CG 199) c. high d. To assess the long-term effectiveness of an online smoking cessation programme	a. Adult smokers who are willing to quit b. IG: 35.9 (SD=10.0); CG: 36.4 (SD=10.5) c. IG 49.2% male; CG: 50.2% male d. IG: 18.3 (SD=5.9); CG: 18.1 (SD=5.8)	Happy Ending (HE), an intense 1-year smoking cessation programme	A self-help booklet plus free nicotine replacement therapy.	Participants in IG reported statistically significantly higher repeated PARs than CG (22.3% versus 13.1%; ITT: OR = 1.91, 95% CI: 1.12–3.26, p value=0.02).  Among those who were currently smoking, participants in IG showed an increase in self-efficacy (M = 0.10, SD = 1.85), while the CG showed a decrease in self-efficacy (M = -0.63, SD = 1.42), which suggests that HE reduces the negative effect that a failure to quit has on self-efficacy.
a. Carrasco-Hernandez et al. (2020) b. Spain c. 6	a. Open-label, parallel-group RCT b. 240 (IG 120; CG 120) c. high d. To analyse the long-term efficacy of a mobile app	a. Adult smokers b. IG: 48.38 (SD=9.49); CG: 50.93 (SD=10.85) c. IG: 45.8% male; CG: 56.7% male d. IG: 21.45 (SD=8.97); CG: 20.75 (SD=9.39)	Usual care plus a mobile app generating smoking cessation messages	Usual care (psychological and pharmacological treatment)	ITT: AR was 2.15 times higher among IG participants than among CG participants  The logistic regression analysis results for participants who completed the study (per-protocol basis) showed that, for the IG participants, the efficacy was 3.45 times higher with adjustment for age, motivation to stop smoking (Richmond scale)
a. Chan et al. (2015)	a. Single-blind, 3-arm RCT	a. Adult smokers b. N/A	Telephone counselling (TEL) group: 5-min	A smoking cessation booklet	ITT: The 7-day PAR for the three groups at 6-month follow-up was 22.2 (TEL), 20.6 (SMS) and 20.3% (CG). OR: TEL group: 1.58, SMS

<p>b. Hong Kong (China)</p> <p>c.7</p>	<p>b. 1003 (Intervention: 338; SMS: 335; Control: 330)</p> <p>c. medium</p> <p>d. To examine the effectiveness of brief interventions for smokers who joined the Hong Kong Quit to Win Contest to quit smoking</p>	<p>c. TEL: 80.8% male; SMS: 80.6% male; Control: 83.9% male</p> <p>d. 1-10: 41.1%, 42.2%, 44.0% 11-20: 42.3%, 44.6%; 41.6% &gt;20: 16.6%, 13.3%, 14.4%</p>	<p>nurse-led telephone counselling and a smoking cessation booklet</p> <p>SMS group: eight text messages through mobile phone and a smoking cessation booklet</p>		<p>group: 1.17. The difference was statistically insignificant between TEL and CG, and SMS and CG</p> <p>The self-reported 7-day PAR at 12-month follow-up: 19.5 (TEL), 17.9 (SMS), 18.2% (CG). OR: TEL: 1.09; SMS: 0.98</p>
<p>a. Cummins et al. (2016)</p> <p>b. USA</p> <p>c. 8</p>	<p>a. Two-arm RCT</p> <p>b. 1173 (IG: 584; CG: 589)</p> <p>c. high</p> <p>d. To test the efficacy of pregnancy-specific counselling.</p>	<p>a. Pregnant smokers</p> <p>b. 18-24: 46.8% (IG 47.4%; CG 42.1%) &gt;=25: 53.2% (IG 48.5%; CG: 49.8%)</p> <p>c. 100% female</p> <p>d. N/A</p>	<p>Telephone counselling plus a self-help packet.</p>	<p>self-help packet only</p>	<p>ITT: AR was higher for the IG than the CG at the end of pregnancy (30-day prolonged AR, 29.6% vs 20.1%; p&lt;0.001), (Risk Ratio (RR)=1.5 (95% CI 1.2-1.8)); 2 months postpartum (90-day prolonged AR, 22.1% vs 14.8%; p&lt;0.001), RR= 1.5 (95% CI 1.2-2.0); and 6 months postpartum (180-day prolonged AR, 14.4% vs 8.2%; p&lt;0.001), RR=1.7 (95% CI 1.2-2.4).</p>
<p>a. Haug et al. (2011)</p> <p>b. Germany</p> <p>c. 9</p>	<p>a. Quasi RCT</p> <p>b. 477: IG 242; CG 235</p> <p>c. high</p> <p>d. To test the feasibility and efficacy of a smoking cessation programme</p>	<p>a. Adult smokers</p> <p>b. 46.5 (SD=9.8): IG-47.0 (SD=9.9); CG-45.9 (SD=9.6)</p> <p>c. 48% male: IG-44.6% male; CG 51.5% male</p> <p>d.14.1 (SD=7.2): IG-14.3 (SD=7.5); CG-13.9 (SD=6.9)</p>	<p>An internet-based programme</p>	<p>Assessment only</p>	<p>ITT: At 6-month follow-up, 7-day PAR was 11.1% (26/235 participants) in the CG and 23.6% (57/242 participants) in the IG.</p> <p>Logistic regression analyses resulted in higher 7-day PAR in the IG compared to the CG (OR=2.0; 95% CI 1.1–3.8; p=.02).</p>

<p>a. Harrington et al. (2016)</p> <p>b. USA</p> <p>c. 10</p>	<p>a. Two-arm RCT</p> <p>b. 1488 (IG-748; CG-740)</p> <p>c. high</p> <p>d. To examine the effectiveness of a web-based smoking-cessation intervention</p>	<p>a. Adult smokers stayed in a hospital</p> <p>b. 41.6 (SD=13.1); IG-41.6 (SD=13.3); CG-41.6 (SD=13.0)</p> <p>c. 52% male: IG-54.7% male; CG-49.3% male</p> <p>d. 14.1 (SD=9.9): IG- 13.6 (SD=9.3); CG- 14.6 (SD=10.4)</p>	<p>Access to a website with communication with a tobacco counsellor, interactive self-assessments, smoking cessation information, and access to online resources, as well as automated email messages tailored for health concern and readiness to quit.</p>	<p>Brief bedside advice to quit, a quit plan template, and quitline contact information</p>	<p>ITT: No difference was found between IG and CG for self-reported ARs (25.4% WI vs 26.8% UC). However, more than 45% of continued smokers reported a reduction in their smoking.</p>
<p>a. McDonnell et al. (2011)</p> <p>b. USA</p> <p>c. 11</p>	<p>a. Two-arm RCT</p> <p>b. 1409 (IG-702; CG-707)</p> <p>c. high</p> <p>d. To evaluate the effectiveness of <i>Quitting is Winning</i> programme</p>	<p>a. Adult Korean American (KA) smokers</p> <p>b. 35.3 (SD=8.9)</p> <p>c. 87.7% male</p> <p>d. 13.8 (SD=7.2)</p>	<p>Online version of the <i>Quitting is Winning</i> programme</p>	<p>Programme booklet</p>	<p>There was no significant difference in 7-day and 30-day PAR between the IG and CG at 50-week follow-up: 7-day PAR: OR=1.0 (95% CI 0.7-1.4); 30-day PAR: OR=0.9 (95% CI 0.6-1.2)</p>
<p>a. Naughton et al. (2014)</p> <p>b. UK</p> <p>c. 12</p>	<p>a. Two-arm RCT</p> <p>b. 602 (IG-299; CG-303)</p> <p>c. high</p> <p>d. To estimate the effectiveness, feasibility and acceptability of a smoking cessation intervention</p>	<p>a. Adult smokers</p> <p>b. 41.8 (SD=13.0): IG-42.3 (SD=13.0); CG-41.3 (SD=13.0)</p> <p>c. 49.3% male: IG-46.8 male; CG 47.9% male</p>	<p>Usual care plus a tailored advice report and text messages</p>	<p>Usual care (Smoking cessation advisors providing advice)</p>	<p>No significant difference between IG and CG in 2-week PAR at the 8-week primary endpoint (OR = 1.22, 95% CI = 0.88–1.69)</p> <p>Statistically significant group differences were found for 6-month prolonged AR at 6 months (OR = 1.81, 95% CI 1.09-3.01) and for 6-month repeated abstinence (control 6.3%, iQuit 11.4%; OR = 1.92, 95% CI 1.07-3.45).</p>

		d. 18.3 (SD=8.0): IG-18.4 (SD=7.9); CG- 18.2 (SD=8.2)			
a. Nguyen Thanh et al. (2019) b. France c. 13	a. Two-arm RCT b. 2478(IG-1242; CG-1236) c. high d. To assess the effectiveness of a personalised and automated Internet-based programme	a. Adult smokers b. 35.9 (SD=9.8); IG-36.2 (SD=9.8); CG-35.6 (SD=9.7) c. 35.2% male: IG 34.3% male; CG 36.0% male d. 16 (SD=7.8)	An automated programme of 45 e-mails (“e-coaching”) sent over a 3-month period	A smoking cessation booklet	ITT: Not significantly different between the IG and CG at 6 and 12 months but was higher in the IG at 3 months than in the CG OR= 1.24 (95% CI 1.03-1.49), 1.00 (95% CI 0.83-1.20), 1.02 (95% CI 0.84-1.24), respectively, at 3 months, 6 months, 12 months.
a. O’Connor et al. (2020) b. Ireland c. 14	a. 3-arm RCT b. 150 (50,50, 50 in IG-app + acceptance and commitment therapy (ACT); CG 1- ACT; CG 2-behavioral support) c. high d. To evaluate the efficacy of a smoking cessation app	a. Adult smokers b. IG, CG1, CG2: [35.99 (9.92); 34.06 (10.14); 35.08 (8.72); 38.80 (10.37)] c. IG, CG1, CG2 (male): 47.34%; 54%; 50%; 38% d. IG, CG1, CG2: 16.85 (7.77); 16.78 (6.51); 16.66 (6.00); 17.10 (10.26)	SmartQuit app plus acceptance and commitment therapy (ACT) treatment	CG1: ACT treatment CG2: behavioural support group	There was no significant difference in the biochemically verified 7-day PAR at 6-month follow-up between IG and CG1, and IG and CG2. At 6-month follow-up, the biochemically verified AR was 24% in the IG versus 24% in the CG1, OR = 1.00, 95% CI 0.40-2.51, and 20% in the CG2, OR = 0.79, 95% CI 0.31-2.05.
a. Schuck et al. (2014) b. Netherlands	a. Two-arm RCT b. 512 (IG 256; CG 256) c. high	a. Smoking parents b. 42.2 (SD=5.4): IG-42.3 (SD=5.6); CG-42.0 (SD=5.1)	Telephone counselling plus tailored supplementary materials	Self-help booklet	ITT: 7-day PAR at 12-month follow-up (OR = 2.35, 95% CI = 1.56-3.54). 7-day PAR at 3-month follow-up (OR = 5.83, 95% CI = 3.72–9.13)

c.15	d. To test the effectiveness of tailored telephone counselling	c. 47.5% male: IG-48.8% male; CG-46.1% male  d. 16.2 (SD=7.8): IG- 15.7 (SD=8.0); CG-16.8 (SD=7.7)			6 months prolonged AR at 12-month follow-up (OR = 4.92, 95% CI = 2.71-8.93).
a. Skov-Ettrup et al. (2016)  b. Denmark  c. 16	a. 4-arm RCT  b. 1810 (Proactive counselling-452; reactive counselling-453; Internet-based program-453; booklet/control-452)  c. high  d. To compare the effectiveness of proactive telephone counselling, reactive telephone counselling and an internet- and text-message-based intervention with a self-help booklet for smoking cessation	a. Adult smokers  b. IG1-51 (41-60); IG2-51 (42-60); IG3-52 (42-59); CG-53 (41-62)  c. Male rate: IG1-38.9%; IG2-43.5%; IG3-41.3%; CG-42.6%  d. IG1-16 (10-20); IG2-17 (10-20); IG3-15 (10-20); CG-15 (10-20)	IG1- Proactive telephone counselling IG2- Reactive telephone counselling IG3- Internet- and text-message-based smoking cessation program (e-quit)	CG- Self-help booklet	The OR for prolonged AR at 6-month follow-up in the IG1 compared to CG was 2.2 (95% CI = 1.2–3.8]) after 6 months and 2.2 (95% CI = 1.2–4.0) after 12 months.  The 30-day PAR was significantly higher in IG1 than in CG after 1 month (OR = 2.7, 95% CI = 1.8-4.1) and 6 months (OR = 1.8, 95% CI = 1.2-2.8).  After 12 months, no statistically significant differences in 30-day PAR were seen for any IG compared to the CG.  For IG1, a subgroup effect was found on 30-day PAR at 12-month follow-up: Compared to those who completed no sessions of proactive telephone counselling, the OR for 30-day PAR at 12 months was 2.7 (95% CI = 1.2–6.1) among those completing at least five sessions.
a. Smit et al. (2012)  b. Netherlands  c. 17	a. Two-arm RCT  b. 1123 (IG-552; CG-571)  c. high  d. To investigate the effects of a web-based	a. Adult smokers  b. 49.5 (SD=32.5): IG-48.4 (SD=12.2); CG-48.8 (SD=12.3)  c. 47.6% male: IG-45.8%; CG-49.4%	Web-based smoking cessation programme	No intervention	ITT: IG appeared to have significantly increased 24-hour PAR (OR 1.85, 95% CI 1.30–2.65), 7-day PAR (OR 2.17, 95% CI 1.44–3.27), and prolonged AR (OR 1.99, 95% CI 1.28–3.09) reported after 6 weeks.  At 6-month follow-up, no intervention effects could be identified. 24-hour PAR (OR 1.51, 95% CI 0.97-2.35), 7-day PAR (OR 1.40, 95%

	smoking cessation programme	d.20.6 (SD=12.4); IG-20.8 (SD=13.7); CG-20.4 (SD=11.0)			CI 0.88-2.22), prolonged AR (OR 1.26, 95% CI 0.68-2.34)
a. Smit et al. (2016) b. Netherlands c. 18	a. Three-arm RCT b. 414: IG1-163; IG2-132; CG-119 c. medium d. To investigate the effects of web-based smoking cessation programme plus counselling (MTC) compared with computer tailoring without counselling (MT) and usual care (UC) on ARs	a. Adult smokers b. 48.0 (SD=11.9): IG1-48.1 (SD=12.0); IG2-47.8 (SD=12.4); CG-48.1 (SD=11.3) c. 40.1% male: IG1-36.8%; IG2-41.7%; CG-42.9% d. N/A	IG1 (MTC): web-based smoking cessation programme plus counselling IG2 (MT): The smoking cessation programme as IG1 without counselling	Usual care: smoking cessation guidance according to Dutch standard practice	At both follow-ups, no main effects of the interventions could be identified .  At 6-month follow-up (24-hour PAR, 7-day PAR, prolonged AR):  MTC vs. MT: OR= 0.670 (95% CI 0.302–1.487), 0.477 (95% CI 0.204-1.115), 0.730 (95% CI 0.304-1.756)  MTC vs. UC: OR= 1.090 (95% CI 0.496-2.396), 0.835 (95% CI 0.353 1.979), 0.804 (95% CI 0.336-1.924)  MT vs. UC: OR= 1.627 (95% CI 0.674-3.931), 1.751 (95% CI 0.679-4.512), 1.100 (95% CI 0.427-2.834)  At 12-month follow-up (24-hour PAR, 7-day PAR, prolonged AR):  MTC vs. MT: OR= 0.519 (95% CI 0.235-1.066), 0.511 (95% CI 0.254-1.028), 0.491 (95% CI 0.224-1.073)  MTC vs. UC: OR= 0.839 (95% CI 0.382-1.846), 0.889(95% CI 0.412-1.914), 0.755 (95% CI 0.319-1.785)  MT vs. UC: OR= 0.618 (95% CI 0.279-1.367), 1.738 (95% CI 0.809-3.734), 1.539 (95% CI 0.669-3.540)

<p>a. Wang et al. (2019)</p> <p>b. Hong Kong (China)</p> <p>c. 19</p>	<p>a. Cluster-RCT</p> <p>b. 1185, Intervention (n=591), Control (n=594)</p> <p>c. high</p> <p>d. To assess the effect of chat-based instant messaging support</p>	<p>a. Adult smokers</p> <p>b. Mean=41.5 (SD=14.0)</p> <p>c. 77% male</p> <p>d. 1-10 (54%,52%) 11-20 (39%, 40%) 21-30 (4%, 4%) &gt;=31 (3%, 4%)</p>	<p>Chat-based instant messaging support for 3 months</p>	<p>Brief advice only</p>	<p>At the 6-month follow-up, validated AR was significantly higher in the IG than in the CG (unadjusted OR= 1.68, 95% CI 1.03–2.74)</p>
<p>a. Xia et al. (2020)</p> <p>b. Hong Kong (China)</p> <p>c. 20</p>	<p>a. Single-blind, 3-arm, RCT</p> <p>b. 1023, video (n=333), text (n=322), control (n=368)</p> <p>c. high</p> <p>d. To examine the effectiveness of a video-based smoking cessation intervention</p>	<p>a. Expectant fathers who are smokers</p> <p>b. Video; Text; Control [31.6(SD=5.5); 31.9 (SD=5.3); 32.5 (SD=5.2)]</p> <p>c. 100% male</p> <p>d. &lt;=10: 72.7%; 72.6%; 75.0% 11-20: 25.2%; 25.2%; 24.4% &gt;=21: 2.1%; 2.2%; 0.5%</p>	<p>IG1- Video group: participants received 4 videos on various risks of smoking for maternal and child health via WeChat on week 1,3,5,7</p> <p>IG2- Text group: participants received 4 text messages with content similar to that of the videos and on similar schedules</p>	<p>Following receipt of the leaflet at baseline, participants received no further intervention</p>	<p>According to the ITT analysis, at 6-month follow-up, OR value (biochemically validated, self-reported):</p> <p>Video vs. Text: 1.66 (95% CI 1.11-2.47), 1.55 (95% CI 1.06-2.27)</p> <p>Video vs. Control: 2.86 (95% CI 1.85-4.42), 2.54 (95% CI 1.69-3.81)</p> <p>Text vs. Control: 1.72 (95% CI 1.08-2.75), 1.63 (95% CI 1.06-2.52)</p>
<p>a. Yu et al. (2017)</p> <p>b. China</p> <p>c. 21</p>	<p>a. 3-arm RCT</p> <p>b. 342 (114 in each group)</p> <p>c. high</p> <p>d. To assess whether interventions that</p>	<p>a. Families of which fathers are smokers and mothers are non-smokers</p> <p>b. Fathers: 31.8 (SD=4.5); IG1-31.8 (SD=4.8); IG2- 31.9</p>	<p>IG1: in-person counselling by trained healthcare workers</p> <p>IG2: counselling in IG1 plus text messaging</p>	<p>No tobacco control intervention</p>	<p>ARs at 6 months (OR: 3.60, 95% CI: 1.41–9.25) and 12 months (OR: 2.93, 95% CI: 1.24–6.94) were both significantly increased in IG1 compared to CG.</p> <p>Not any significant difference in the outcomes neither between control group and traditional intervention group (CG and IG1), nor the</p>

	incorporate traditional and mobile phone- based education will help create smoke-free homes for infants and increase quitting among fathers	(SD=4.1); CG-31.6 (SD=4.5) Mothers: 29.6 (SD=3.8); IG1-29.6 (SD=3.8); IG2-29.9 (SD=3.8); CG-29.3 (SD=3.7)  c. N/A  d. N/A			difference between traditional intervention group and mHealth intervention group (IG1 and IG2).
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<sup>a</sup>. ITT: intention-to-treat analysis <sup>b</sup>. CAR: continuous abstinence rate <sup>c</sup>. PAR: point abstinence rate <sup>d</sup>. CO: carbon oxide <sup>e</sup>. OR: odds ratio <sup>f</sup>. CI: confidence interval <sup>g</sup>. SD: standard deviation <sup>h</sup>. RCT: randomised controlled trial <sup>i</sup>. IG: intervention group <sup>j</sup>. CG: control group <sup>k</sup>. RR: risk ratio

#### 5.4.2 Long-term effectiveness of mHealth interventions in smoking cessation

It is worth emphasising that this systematic review, as one of the steps in formulating IPTs, focuses on analysing what affects the long-term effectiveness of mHealth interventions in smoking cessation. Therefore, the review findings were grouped under different influencing factors that may have caused the success or failure of smoking cessation interventions. Due to the inconsistency in methods for assessing abstinence status, I did not differentiate between self-reported and biochemically verified ARs in this review, but I have listed them in Table 5.2.

##### 5.4.2.1 Sustained user engagement

User engagement was found to be an important factor that may lead to the success or failure of smoking cessation interventions (McDonnell et al., 2011, Smit et al., 2012, Naughton et al., 2014, Smit et al., 2016, Cummins et al., 2016, Harrington et al., 2016, Baskerville et al., 2018b). Lack of sustained user engagement was one of the reasons why mHealth interventions were effective in the short term (follow-up less than six months) but not in the long term. Smit et al. (2012) certified the short-term effectiveness of mHealth interventions, but the effects were undermined in the long term. They found that the web-based tailored intervention was effective in increasing short-term ARs (24-hour, 7-day PAR, and prolonged AR at 6-week follow-up), but no effect was found at 6-month follow-up (OR value shown in Table 5.3). The web-based intervention involved asking smokers to set a quit date before the programme started and providing relevant and personalised online feedback based on the questionnaire they completed at each follow-up. The questionnaire included assessments of their intentions to quit, self-efficacy, strategies for relapse prevention, etc., to comprehensively evaluate the participants' smoking cessation progress. In this study, only 40% of participants completed the 6-week follow-up questionnaire, and the completion rate dropped further to 25.9% for the 6-month follow-up questionnaire. The high attrition rate and low engagement level might have affected the long-term effectiveness of the intervention and also suggested that further strategies may be needed to enhance sustained user engagement when implementing mHealth interventions.

Compared with Smit et al. (2012), Smit et al. (2016) added another intervention group, which combined the mHealth intervention and traditional counselling. Both intervention groups in Smit et al. (2016) utilised the web-based programme that was employed in Smit et al. (2012), with one group including tailored counselling by practice nurses (MTC group), while the other did not (MT group). The control group was provided with smoking cessation guidance, with the intensity varying from brief advice to intensive counselling sessions with practical nurses. The study found no significant differences in ARs at either 6-month or 12-month follow-ups (OR value presented in Table 5.3). One possible reason might be that the frequency of counselling sessions in the MTC group was too low, offering only one session at the 6-week follow-up and one telephone follow-up at six months. Another potential reason could be that the intensity of guidance in the control group was too high, making the comparative effectiveness of the mHealth interventions less apparent. These two reasons both highlighted the importance of the intensity of mHealth interventions. Lastly, the web-based intervention only provided feedback letters after participants filled out the questionnaires at follow-ups rather than offering ongoing support throughout the smoking cessation process. This indicated the importance of mHealth interventions in providing intense support to increase user engagement.

Another study also demonstrated that sustained user engagement was an important indicator of the long-term effectiveness of mHealth interventions in assisting smoking cessation (Cummins et al., 2016). In Cummins et al. (2016), a pregnancy-specific proactive counselling intervention was implemented as an intervention for pregnant women to assist in smoking cessation. The intervention group showed significantly higher ARs compared to the control group, who received self-help materials only. The results were consistent across different time points (at the end of pregnancy, 2 months postpartum, and 6 months postpartum). This study verified both the short-term and long-term effectiveness of the mHealth intervention (statistical data shown in Table 5.3). The first reason for the success might be the specific counselling protocol, which was specifically designed for pregnant smokers, involving pregnancy-related health risks and strategies to manage withdrawal symptoms. This tailored intervention perfectly matched the target population's needs, enhancing its relevance and impact on these smokers. The second reason might be the intense intervention implemented. The intervention group were provided nine counselling

sessions, all with counsellors initiating the calls. This intense, tailored intervention helped maintain the user engagement levels among these pregnant smokers.

When compared with traditional smoking cessation interventions, several studies found that mHealth interventions were not superior in increasing the long-term ARs (McDonnell et al., 2011, Harrington et al., 2016, Baskerville et al., 2018b).

Baskerville et al. (2018b) compared the effectiveness of the Crush the Crave (an evidence-based smoking cessation app) and self-help materials. Crush the Crave incorporated several features mentioned in Chapter 4, including tracking, compensation, social support, etc. However, the authors found that Crush the Crave was less effective than self-help materials (CAR at six months: OR 0.83, 95% CI 0.59-1.18; 30-day PAR at six months: OR 0.82, 95% CI 0.63-1.08). This finding may indicate that the Crush the Crave app was not an ideal alternative to printed materials. The authors analysed that the potential reason could be that self-help materials received higher user satisfaction and perceived helpfulness because participants found them more intuitive and straightforward than the Crush the Crave app. In this study, participants found the app was too complex to use compared with the printed materials, which resonated with the findings of the first review that ease of use was an important factor for the success of mHealth interventions (Chapter 4). This suggested that long-term effectiveness will be negatively affected if mHealth interventions cannot ensure sustained user engagement because they are not as easy as traditional interventions.

In Harrington et al. (2016) to examine the effectiveness of an interactive and semi-tailored web-based smoking cessation intervention, the 30-day PAR at 6-month follow-up was not different between the intervention group (web-based intervention plus usual care) and the control group (usual care only) (AR 25.4% (Intervention) vs 26.8% (Control)). This finding indicated that usual care, including bedside advice, quit plan template, and quitline contact, may act as an intense intervention, diminishing the apparent additional benefit of the web-based intervention. Another possible reason could be the low engagement level of the web-based intervention. Most participants in the intervention group did not actively use the provided online resources, which could have limited the potential impact of the intervention.

McDonnell et al. (2011) conducted a study to evaluate the effectiveness of 'Quitting is Winning program'. In McDonnell et al. (2011), both the intervention and control groups received the same content. The difference was that the intervention group received an online version, while the control group received a printed programme booklet. Given identical intervention content, this study found no significant difference in the 30-day ARs at 50-week follow-up between the two groups (OR 0.9, 95% CI 0.6-1.2). A possible reason for this is that the booklet did not require internet access, making it more accessible and flexible to use. Although no difference in effectiveness was found between mHealth and traditional intervention groups when the intervention content was the same, the study found ARs were higher among participants in the mHealth intervention who completed the online programme compared with those who did not, highlighting the importance of sustained use engagement in mHealth interventions.

Interestingly, Naughton et al. (2014) found that the text message-based intervention was effective in increasing long-term ARs but not short-term ARs. This study observed no significant difference between the intervention group receiving mHealth intervention and usual care and the control group receiving usual care alone. For long-term effectiveness, the OR for 6-month prolonged abstinence at the 6-month follow-up was 1.81 (95% CI 1.09-3.01), indicating a noteworthy impact of the mHealth intervention on sustained smoking cessation. The reason might be the sustained user engagement caused by tailored advice and text messages and integration with routine smoking cessation support in primary care. In studies that found that mHealth interventions only had short-term effects and were less effective in supporting long-term abstinence, maintaining sustained engagement over the long term was a significant challenge.

#### *5.4.2.2 Boosted motivation to stop smoking*

Several studies found the different long-term effectiveness between proactive and reactive counselling, which may indicate that one of the outcomes of using mHealth interventions in smoking cessation was increasing motivation to stop smoking. Abdullah et al. (2005) found that proactive telephone counselling, where counsellors contacted smokers initially, was effective for helping unmotivated smokers quit at the

6-month follow-up. This indicated that proactive counselling appeared to boost the motivation of smokers to stop smoking. The authors compared their results with another study on reactive counselling and found ARs were higher among proactive telephone counselling. The reason might be that reactive counselling, in which smokers initiate the contact, generally attracts smokers who are already motivated to quit smoking. Therefore, the effectiveness of the intervention in enhancing smokers' motivation was not as apparent as in proactive counselling.

The finding that unmotivated smokers may benefit more from mHealth interventions was certified in another included study (Wang et al., 2019). In the study to assess the effect of a chat-based instant messaging support intervention, Wang et al. (2019) found that participants who were not motivated to quit within the past 30 days benefited more from the mHealth intervention. In this study, the focus of the chat-based intervention was to use acceptance and commitment therapy (ACT) to identify a value that could help increase the participant's commitment to quitting smoking, The ACT-based intervention was more effective in participants without a motivator to quit because it helped them identify and connect with the values that were important to them, which boosted their motivation to quit.

Another study also confirmed that increased motivation was an important predictor of the success of mHealth interventions in smoking cessation (Skov-Ettrup et al., 2016). To compare the effectiveness of proactive telephone counselling, reactive telephone counselling and internet- and text-message-based intervention with a self-help booklet for smoking cessation, Skov-Ettrup et al. (2016) only found a significant difference in the prolonged AR at 12-month follow-up between the proactive counselling group and the booklet group (OR=2.2, 95% CI 1.2-4.0). No statistically significant differences were found in other groups.

#### *5.4.2.3 Increased self-efficacy*

In addition to increasing ARs, other indicators, including increased self-efficacy, can also serve as evidence of the effectiveness of mHealth interventions (Abdullah et al., 2005, Clyde et al., 2017). Included studies also reported these indicators of the effects of mHealth interventions, regardless of the difference in ARs between the

intervention group and control group (Brendryen et al., 2008, Brendryen and Kraft, 2008, Schuck et al., 2014, Harrington et al., 2016).

In Harrington et al. (2016) to assess the effectiveness of a semi-tailored web-based smoking cessation intervention, although no significant difference in long-term ARs was found between the mHealth intervention group and the control group (statistical data shown in Table 5.3), this study identified important variables associated with the success of smoking cessation, including higher self-efficacy level. Harrington et al. (2016) reported that 45% of continued smokers in the web-based intervention group became less dependent on smoking, which could be a good sign of moving from an unmotivated smoker to a motivated smoker. At the same time, the researchers collected psychosocial factors related to smoking cessation from the participants and found that those who were confident in quitting had higher smoking cessation rates at six months.

Brendryen and Kraft (2008) found participants in the mHealth group had higher self-efficacy after smoking cessation than participants in the control group (IG: mean = 5.10, SD = 1.41; CG: mean = 4.38, SD = 1.31;  $t_{379} = 5.18$ ,  $P < 0.001$ ). In addition, the mediation analysis was conducted in Brendryen et al. (2008), and the results showed that participants in the intervention group increased their self-efficacy (Pearson  $r = 0.54$ ,  $P < 0.001$ ). The increased self-efficacy might be the explanation for the increased levels of coping planning to manage cravings (Pearson  $r = 0.32$ ,  $P < 0.001$ ).

### 5.5 Evidence synthesis of outcomes of using mHealth interventions in smoking cessation

The long-term effectiveness of mHealth interventions in smoking cessation varied in this review. Different outcomes that happened to smokers might be responsible for the heterogeneity in the effectiveness of these interventions. For example, the differences in the effectiveness of proactive versus reactive counselling highlighted the effect of mHealth interventions for smokers who initially have low motivation and increased motivation is frequently noted as a common outcome after the implementation of these smoking cessation interventions (Abdullah et al., 2005, Skov-Ettrup et al., 2016, Wang et al., 2019).

Increased self-efficacy was observed in the mHealth intervention group in the included studies (Brendryen et al., 2008, Brendryen and Kraft, 2008, Schuck et al., 2014, Harrington et al., 2016). Although the studies did not provide an explanation for increased self-efficacy (the underlying mechanism), it can be inferred that enhanced self-efficacy was one of the outcomes of using mHealth interventions in the included studies. The first systematic review (Zhang et al., 2023) found that the tracking feature of smoking cessation apps allowed smokers to understand their craving patterns better, and the compensation feature displayed progress in quitting as well as the benefits derived from quitting smoking. These findings suggested that mHealth interventions potentially can increase self-efficacy by providing insights into their smoking behaviours and quitting progress, which not only boosted their confidence in the ability to keep abstinence in the long term but also helped them more effectively manage high-risk situations encountered during smoking cessation.

In addition, sustained user engagement was an important outcome for the success of mHealth interventions in smoking cessation (McDonnell et al., 2011, Smit et al., 2012, Naughton et al., 2014, Smit et al., 2016, Cummins et al., 2016, Harrington et al., 2016, Baskerville et al., 2018b). Included studies identified that tailored mHealth intervention and ease of use were linked with sustained user engagement (section 5.3.2.1), thereby increasing the long-term ARs. This finding was consistent with the first qualitative systematic review (Zhang et al., 2023), which emphasised that smoking cessation apps that are easy to use and personalised were expected by smokers. Previous research has found that ease of use and personalisation are important attributes to improve usability and user experience (O'Brien and Cairns, 2016, Davies and Mueller, 2020). When users find the intervention easy to use, they are more likely to utilise it effectively, enhancing the overall effectiveness of the intervention in achieving its intended goals (O'Brien and Cairns, 2016). In addition, personalisation in mHealth interventions allowed for interventions to be specifically adapted to the smokers' unique needs (Davies and Mueller, 2020).

Intensity of intervention is another predictor of sustained user engagement (Chan et al., 2015, Smit et al., 2016). This finding was also supported by other studies that found high-frequency text messaging interventions were effective in increasing long-

term AR (Rodgers et al., 2005, Free et al., 2011, Abrams et al., 2014). For example, Free et al. (2011) found that a mobile phone-delivered text messaging intervention, which provided one text message per day for the first five weeks and three messages per week for the following 26 weeks, was effective in increasing CAR at 6-month follow-up. In Abrams et al. (2014), participants received five messages on the quit date. In the first week after the quit date, they received two messages per day. For the next two months, they continuously received three messages per week. In this study, the 30-day PAR among the intervention group (a text-messaging programme) was higher than the control group (Risk ratio 1.57, 95% CI 1.10-2.26).

Overall, the review findings suggested that boosted motivation to quit smoking, increased self-efficacy, and sustained user engagement were outcomes of using mHealth interventions in smoking cessation.

## 5.6 Discussion

This review synthesised the current evidence on the outcomes of using mHealth interventions in smoking cessation. While the first systematic review identified common features and characteristics of smoking cessation apps, linking the findings of this review provided more comprehensive insights on how mHealth interventions can assist smokers in quitting. The findings of this review supported that different mHealth smoking cessation interventions showed heterogeneity in long-term effectiveness. Overall, potential outcomes caused by the use of mHealth interventions in smoking cessation were sustained user engagement, boosted motivation, and increased self-efficacy.

Increased motivation to quit was one of the intended outcomes of using mHealth interventions in smoking cessation, which could be explained by the Protection Motivation Theory (PMT) (Chapter 2) (Rogers, 1975). PMT provides valuable insight into how smokers make decisions to stop smoking through a balance of two cognitive pathways. It emphasises the importance of smoking cessation interventions incorporating strategies to strengthen smokers' motivation so they can adopt protective behaviour (smoking cessation).

Another intended outcome was increased self-efficacy. Previous research also found self-efficacy was an important indicator of successful smoking cessation (Gwaltney et al., 2005, Gwaltney et al., 2009, Yan et al., 2014, Hopkins et al., 2022). For instance, Gwaltney et al. (2009) found that higher self-efficacy was consistently associated with greater success in quitting smoking. Similarly, Gwaltney et al. (2005) found that smokers who reported higher self-efficacy were more likely to quit smoking and remain abstinent. One potential explanation for the relationship between self-efficacy and smoking abstinence is that individuals with higher self-efficacy can cope with the challenges and difficulties associated with quitting smoking (Gwaltney et al., 2009, Rajani et al., 2021b). For example, they may be more likely to engage in problem-solving strategies, seek social support, and resist the temptation to smoke in high-risk situations (Gwaltney et al., 2005).

Transtheoretical Model (TTM) might also support the relationship between self-efficacy and successful smoking cessation (Chapter 2) (Prochaska and DiClemente, 1982). According to TTM, from the pre-contemplation stage to the termination stage, a smoker's self-efficacy gradually increases from 0% to 100% (Prochaska, 2008). This progression reflects the process of moving from a lack of confidence in their ability to stop smoking to totally confident in maintaining a new, healthy lifestyle.

To resonate with the first systematic review (Zhang et al., 2023), this review found personalisation and ease of use play an important role in maintaining user engagement to assist smokers in stopping smoking in the long term. Although this review found that user engagement level was an important predictor of the success of mHealth interventions, it should be noted that counterproductive engagement and productive disengagement can co-exist during the use of smoking cessation interventions (Smith et al., 2017). For example, frequent text messages can have counterproductive effects on smokers by evoking cravings (Schick et al., 2018, Bendotti et al., 2022, Peiris et al., 2019, Luna-Perejon et al., 2019).

Outcome measurements are crucial aspects of evaluating the effectiveness of smoking cessation interventions (Cheung et al., 2017). Among the 21 included studies, only seven studies used a biochemically verified method to assess ARs. Most studies used self-reported measurements, and the most standard measure was

self-reported 7-day point ARs. Relying on self-reported abstinence can lead to overestimation of the intervention effect and reduce the reliability of the study findings (West, 2005, Cheung et al., 2017). In addition, the paucity of consistency in outcome measurements across studies made it challenging to compare the results and draw definitive conclusions about the effectiveness of mHealth interventions. Therefore, it is crucial for future studies to adhere to a standardised outcome measurement protocol (Cheung et al., 2017) to facilitate the comparability and generalizability of study findings.

Several recommendations are provided based on the review findings. Firstly, further rigorous experimental research that adheres to the standard smoking cessation outcome measurement protocol (Cheung et al., 2017), should be conducted. Secondly, although increased user engagement level is one of the intended outcomes of using mHealth interventions, the relationship between user engagement level and long-term ARs is still unclear, which needs further research to explore it.

## 5.7 Strengths and limitations

This review has several strengths, such as the robust search strategy used, multiple reviewers involved in screening, quality appraisal, data analysis, and following best practice guidelines, PRISMA, for reporting results. However, some limitations exist in this review. Firstly, theses, dissertations, and grey literature were excluded for pragmatic reasons. It is possible that studies that could contribute data to fully examine the evidence in the outcomes of using mHealth interventions in smoking cessation might have been missed. Secondly, only studies published in English were included in this review. Thirdly, most of the included studies were conducted in high-income countries. Given the cultural and social-economic gaps between high-income countries and LMICs, the findings of this review may not apply to LMICs.

## 5.8 Conclusion

This review summarised the outcomes of using mHealth interventions to support smoking cessation. The findings of this review supported that boosted motivation to stop smoking, increased self-efficacy, and sustained user engagement are intended

outcomes of using mHealth interventions to assist smokers in maintaining abstinence in the long term. These findings were used to formulate IPTs in Chapter 6, section 6.7, together with the findings of the first systematic review and interviews with Chinese health workers.

## CHAPTER SIX: Interviews with Chinese health workers

### 6.1 Introduction

This is the third step of formulating IPTs, which involved health workers' interviews to provide insights into how smoking cessation apps could work for smokers in the Chinese context. Two systematic reviews have been conducted preceding this step, and findings were presented in chapters 4 and 5. This chapter begins by outlining the participants' characteristics and presenting themes that emerged from the interview data. Following this, the findings of the interviews were presented. Selected quotes were used to illustrate the findings. At the end of this chapter, the findings of this chapter were brought together with the contexts, mechanisms, and outcomes identified in Chapters 4 and 5 to construct IPTs in both the 'if...then...because...' statements and CMOCs.

### 6.2 Participants characteristics

Six health workers whose roles involved assisting smokers in stopping smoking were recruited and interviewed. The interviews lasted 35 to 60 minutes. The participants' details are presented in Table 6.1.

No.	Occupation	Organisation
1	Nurse	Hospital
2	Smoking cessation counselor with nursing background	Smoking cessation clinic
3	Doctor	Hospital
4	Doctor	Hospital
5	Nurse	Hospital
6	Doctor	Hospital

Table 6.1 Participants' details (Health workers)

### 6.3 Themes

Qualitative interview data were analysed through a combined approach of inductive and deductive methods (Chapter 3). This meant that I could start with the identified

contexts, mechanisms, and outcomes, using these assumptions to interpret the data, ensuring that the research direction and structure aligned with existing theories (deductive coding). In addition, I also allowed room for coding new ideas and concepts to be generated from the interview data, gaining new insights and understandings that were not anticipated before, making the analysis more comprehensive and in-depth (inductive coding). Overall, three themes emerged from the analysis. The themes and sub-themes are outlined in Table 6.2.

Themes	Sub-themes	Approach
<ul style="list-style-type: none"> <li>Barriers to smoking cessation in China</li> </ul>	<ul style="list-style-type: none"> <li>Lack of knowledge</li> <li>Lack of motivation</li> <li>Negative emotions</li> <li>Chinese smoking culture</li> </ul>	Inductive
<ul style="list-style-type: none"> <li>Perceived benefits of smoking cessation apps</li> </ul>	<ul style="list-style-type: none"> <li>Positive psychological hints</li> <li>Social support</li> </ul>	Deductive
<ul style="list-style-type: none"> <li>Worries about smoking cessation apps</li> </ul>		Inductive

Table 6.2 Development of themes (Health worker interviews)

#### 6.4 Barriers to smoking cessation in China

This theme describes the challenges faced by Chinese smokers who attempt to quit smoking in the context of China.

##### 6.4.1 Lack of knowledge

Insufficient knowledge of the risks of smoking was a common barrier faced by Chinese smokers (Yang et al., 2010b, Yang et al., 2010a, Zhang et al., 2019). Interview data showed that many Chinese smokers only had a low level of knowledge that smoking is harmful to health, and they did not recognise the fatal effects of smoking. For smoking cessation interventions, it is essential to provide educational knowledge on the risks of smoking to help smokers have a deep and comprehensive understanding of the risks of smoking.

*“Some patients did not fully understand that smoking is harmful to themselves.”*  
(Health worker 04, Doctor)

*“Apps can educate smokers about the risks of smoking, such as what diseases are caused by smoking, and among them, which diseases are fatal. It will definitely help them stop smoking.”* (Health worker 04, Doctor)

Health workers shared their experiences encountering smokers who had misunderstandings about the challenges and outcomes of smoking cessation, so they chose not to start quitting smoking because of the fear of relapse. This fear appears to be not substantiated by existing evidence and current guidelines, as smoking cessation starts to benefit health in the first few minutes (WHO, 2020b), and relapse is a common part of the quitting process (Marlatt and Gordon, 1985). Therefore, any interventions or programmes that aim to assist smokers to stop smoking should provide information about the benefits of quitting through education and reduce the psychological burden caused by relapse.

*“Some Chinese smokers have a misunderstanding about the quitting process. They worry that if they fail and relapse, it might cause even more harm to their body, so they choose not to start quitting.”* (Health worker 03, Doctor)

The self-exempting beliefs caused by this lack of knowledge are common among Chinese smokers (Chapter 2). For example, believing that the negative consequences of smoking will not happen to themselves is a common self-exempting belief. Health workers mentioned that they often met smokers who had the self-exempting belief that smoking was not necessarily linked with getting severe diseases. They thought they would be the lucky ones who escaped from developing smoking-induced diseases.

*“They will think that ‘I have smoked for so many years without getting any diseases, so smoking will not cause any harm to me. Why shall I stop smoking?’”* (Health worker 04, Doctor)

The importance of having a strong understanding of the risks of smoking was emphasised by health workers. From the health workers' point of view, if smokers have a strong knowledge base of the harmful risks of smoking, which can lead to severe diseases, they can be motivated to stop smoking. In other words, this motivation would come from within themselves rather than being forced to stop smoking by their family members or health workers.

*“When they understand what smoking has brought to them, stopping smoking can be a natural thing to happen. They do not need to ‘inhibit’ the cravings or to ‘overcome’ the difficulty in smoking cessation.”* (Health worker 02, Smoking cessation clinic staff)

#### 6.4.2 Lack of motivation

Motivation is the prerequisite for making the decision to stop smoking due to the addictive nature of tobacco use (Rogers, 1975). Interview data showed that health workers held the belief that if smokers lacked the motivation to quit, any smoking cessation interventions would be less likely to be effective. This was because if the smokers were not motivated to quit, they may not actively engage with the provided tools. For example, a health worker mentioned that even if he suggested recording each relapse, smokers who lacked the motivation to quit still ignored this advice.

*“I often advised patients to stop smoking and record each relapse, but if they were not motivated to quit smoking, they would not record it even if they relapsed. They just avoided recording and will not let me know that they have relapsed.”* (Health worker 05, Nurse)

Health workers believed motivation was the driving force that prompted smokers to quit and stay abstinent. When smokers lack motivation, they might find it difficult to resist temptation. For example, a health worker mentioned that even in a strictly non-smoking environment like hospitals, unmotivated smokers will smoke secretly. This indicates that enhancing motivation is crucial in helping smokers quit.

*“Smoking is strictly forbidden in the hospital, but patients will smoke in the toilets or on the balcony secretly...They were not motivated enough.”* (Health worker 05, Nurse)

Health workers noted that smokers who sought help to quit may have different motivators. When asked how to support patients in quitting, one of the health workers mentioned focusing on their motivation and tailoring the support based on their specific reasons for quitting.

*“When patients wanted to quit smoking and seek our help, we first conducted a comprehensive assessment, such as the tobacco dependence level and their main motivations for quitting. We then provided personalised support based on their motivations. For example, a patient told us he wanted to quit because his wife was pregnant. During subsequent telephone follow-ups, we would repeatedly emphasise the harms of secondhand smoke to pregnant women and their fetus.”* (Health worker 01, Nurse)

Overall, motivation is essential for smokers to make the decision to start quitting smoking and successfully resist cravings. Interview data highlighted that without sufficient motivation, smokers are unlikely to engage in smoking cessation interventions effectively. Health workers also emphasised the importance of identifying smokers’ motivations for quitting and providing tailored smoking cessation support.

#### 6.4.3 Negative emotions

Nearly all health workers believed that having negative emotions could be one of the barriers to smoking cessation. Stress from work, anxiety, or other negative emotions could lead to relapse during smoking cessation. Helping smokers alleviate the negative emotions experienced is crucial during the quitting process. As smokers may rely on smoking to cope with adverse emotions in everyday life, health workers highlighted that smoking cessation interventions need to provide alternative ways to help them handle these emotions rather than relying on smoking.

*“Chinese smokers are experiencing massive stress. They need smoking to relieve their pressure.”* (Health worker 02, Smoking cessation clinic staff)

*“Engaging in other activities can alleviate negative emotions. For example, exercising, eating something they enjoy. This is what smoking cessation intervention could suggest smokers to do.”* (Health worker 06, Doctor)

Additionally, negative emotions, including anxiety and irritability, may arise during the start of smoking cessation (CDC, 2022). Health workers indicated that smoking cessation interventions should educate smokers that these reactions are normal, thereby helping smokers better understand and accept the challenges of the quitting process.

*“Apps could have different information regarding the withdrawal symptoms such as the negative emotions, especially for the first two weeks...Smokers will be more knowledgeable and prepared for these symptoms.”* (Health worker 03, Doctor)

Overall, experiencing negative emotions is a significant barrier for Chinese smokers to stop smoking. Therefore, smoking cessation interventions could employ strategies to help smokers distract from these negative emotions or educate them that experiencing negative emotions during the early stage of smoking cessation is normal.

#### 6.4.4 Chinese smoking culture

The last-mentioned barrier is the unique smoking culture in China (Chapter 2). In China, smoking is a normal and widely accepted socialising way, and the sharing and gifting culture is still widespread in Chinese society (Barnett et al., 2022). Smoking is regarded as a way to show kindness or build relationships, making it challenging for Chinese smokers to decline such offers.

*“Many patients said exchanging cigarettes is unavoidable in some social situations, as it is a form of social form in China.”* (Health worker 01, Nurse)

Health worker interview data showed that offering a cigarette becomes a way to express kindness among Chinese smokers. Due to this culture, Chinese smokers often face situations where they feel obligated to accept cigarettes offered by others. In addition, health workers explained that their patients' decisions about smoking cessation might not be understood and supported by other smoking peers in real life. To make things worse, since smoking is a way to show masculinity in China, a male smoker who rejects a cigarette offered by others may be seen as 'feminine', which not only undermines the smoker's self-esteem but also reinforces the societal acceptance of smoking, making it harder to quit. This social pressure will deter Chinese smokers from pursuing their goal to stop smoking due to fear of social isolation or judgment.

*"In traditional Chinese culture, showing kindness through words can be difficult. Sometimes, offering a cigarette can be a way to show kindness. Chinese smokers will face lots of situations where they have to accept the cigarettes offered by others...If one smoker says he stops smoking, then his friends who used to smoke with him will laugh at him, saying he is feminine or something like that."* (Health worker 02, Smoking cessation clinic staff)

*"In China, smoking is a way of socialising.... you know, if you stop smoking, you will be alienated from other people."* (Health worker 03, Doctor)

The deep-rooted smoking culture in China, where smoking is regarded as a social way to show kindness and masculinity, is a huge challenge for smokers to stop smoking (Barnett et al., 2022). Based on this, Chinese smokers may need a more supportive environment to promote smoking cessation. Being in a social environment where everyone supports each other's decision to quit and where 'no smoking' is recognised as the new social norm can be highly beneficial for smokers trying to quit.

## 6.5 Perceived benefits of smoking cessation apps

This theme describes what benefits Chinese smokers can get from using smoking cessation apps, based on health workers' views.

### 6.5.1 Positive psychological hints

The interview data echoed the findings of the two systematic reviews (Chapters 4 and 5) that smoking cessation apps can offer cognitive support by incorporating positive psychological hints that reinforce smokers' motivation to quit. When viewing the quitting progress and health gains within apps, smokers will be more motivated to remain abstinent and become more confident to stop smoking.

When asked about the expected app functions, health workers suggested that smoking cessation apps could send regular reports highlighting positive changes, such as celebrating milestones, showing the health benefits they get since smoking cessation starts, and reminding smokers that their efforts are being paid off. This positive feedback can motivate smokers to keep abstinent.

*“Sending them a weekly or monthly report showing the abstinent days and health gains. They will know their health is improving because of smoking cessation, which is motivating for smokers.”* (Health worker 03, Doctor)

Additionally, another health worker believed that smoking cessation apps could integrate the feature of setting a quit date and calculating the number of smoke-free days based on that date. Tracking smoke-free days can not only help smokers track their quitting progress but also enhance their self-efficacy. Thus, smokers will be more confident in their ability to stop smoking successfully.

*“Apps have the function of checking in on smoke-free days. Smokers can set a quit date, and apps calculate the abstinent days based on the quit date. They will be more confident in their ability to resist cravings and stay abstinent”* (Health worker 01, Nurse)

Health workers also believed that providing virtual rewards, such as a virtual medal to celebrate milestones, can offer immediate positive feedback to smokers. This positive feedback can be another psychological hint for smokers. Smoking cessation is a process that requires prolonged efforts, and its benefits may not be immediately apparent. However, providing virtual rewards to celebrate each small step can be

motivating to smokers since they can get instant feedback on the benefits of smoking cessation.

*“Providing virtual rewards is beneficial because smokers can see their improvements and achievements. It takes a long time for the benefits of smoking cessation to be seen. However, providing a virtual medal to celebrate milestones, such as keeping smoking cessation for one month, would be significant to smokers.”* (Health worker 05, Nurse)

Overall, interview data revealed the health workers' perceptions that smoking cessation apps can be effective by providing positive psychological hints that enhance smokers' motivation to quit and make them more confident about keeping abstinent. App features that show quitting progress and health gains and provide virtual rewards, which make the change visible, can be helpful for Chinese smokers.

### 6.5.2 Social support

According to health workers, providing social support, including emotional support and informational support, is an important function of smoking cessation apps. Interview data also echoed the findings of the two systematic reviews that smoking cessation apps can provide social platforms for smokers to share experiences with others. I have explained in Section 6.4.4 that the distinct smoking culture in China causes a scarcity of social support from social circles in real life, making the smoking cessation journey particularly challenging. The advantage of the social platform within smoking cessation apps lies in all members sharing the goal of quitting smoking. This collective endeavour makes them more easily understand the challenges encountered during the quitting process and enables them to offer empathy and emotional support (Westmaas et al., 2010).

Health workers expressed that in a social group with the common goal of quitting smoking, smokers can support each other, knowing that they are not facing the challenge alone but have other peers showing understanding and empathy. This emotional social support reduces the feeling of loneliness during the smoking cessation process.

*“I think that people in the smoking cessation group can understand the challenges and difficulties of quitting smoking. When smokers share their feelings in the group, others will tell them they have also gone through the same process and encourage them to keep going.”* (Health worker 04, Doctor)

*“Several smokers who were in the same group encouraged each other to stop smoking and shared what positive changes had happened to them due to smoking cessation.”* (Health worker 01, Nurse)

Another form of social support is obtaining information related to quitting smoking from other quitters. Informational social support can take the form of sharing experiences of smoking cessation, which allows them to learn from each other.

*“Smokers also exchanged tips for controlling their cravings in the group. I remember a smoker once said that when he had the urge to smoke, he would do some exercise... There was a smoker once mentioned that distracting themselves from cravings through deep breaths or playing games.”* (Health worker 01, Nurse)

In addition, health workers held the view that successful quitters may act as role models to motivate other smokers. As role models, successful quitters can display their achievements, and it can convey the belief that quitting smoking is achievable. The positive example can boost smokers' confidence and motivation to quit smoking.

*“Successful quitters can share their experiences with other smokers...they are role models, and people can follow their footprints.”* (Health worker 03, Doctor)

Lastly, health workers mentioned that social support can also come from smokers who have relapsed through sharing their failure experience to alert others. Sharing the relapse reasons can be a reminder of high-risk situations so other smokers can keep constant vigilance for these situations. Furthermore, through sharing the regret feelings, smokers can be more determined to remain abstinent to avoid the same regrets.

*“Smokers can learn from both successful and failed experiences...Relapsed people can share their experience so other smokers can be vigilant to cravings.”* (Health worker 06, Nurse)

To summarise, smoking cessation apps can provide a social platform where all members can engage in mutual encouragement and share successful and failed experiences. This social group is essential in providing social support for smokers who need it. This supportive social group not only provides emotional support, making the smoking cessation journey less lonely and providing encouragement to smokers, but also provides informational support that increases smokers’ confidence and motivation to quit smoking.

## 6.6 Concerns about smoking cessation apps

This theme includes health workers' concerns about using smoking cessation apps and their opinions on which aspects of these interventions could be improved to strengthen the effects. Although health workers recognised the advantages of using mobile technology in health fields, they were skeptical about the effectiveness of smoking cessation apps due to their applicability, ease of use, sustainability, and proper app management.

All interviewed health workers had an overall impression that mHealth interventions, including smoking cessation apps, were portable and convenient to use without geographic restrictions.

*“Mobile interventions in health fields, such as smoking cessation, are very portable and convenient.”* (Health worker 01, Nurse)

*“One of the advantages of smoking cessation apps is the convenience. Smokers can use it whenever, at anytime, and anywhere.”* (Health worker 04, Doctor)

However, when asked whether they were optimistic about the effectiveness of smoking cessation apps, they held a conservative attitude, neither believing nor denying the potential of employing smoking cessation apps as an effective

intervention. The first issue they were concerned about was the applicability of smoking cessation apps. One health worker explained that smoking cessation apps may work for young people who are familiar with mobile apps. For those who are not good at using mobile apps, they will be less likely to choose to use smoking cessation apps.

*“Whether smoking cessation apps can work depends on the user population. For example, a smoker aged thirty who is familiar with mobile technology may use smoking cessation apps, but smokers aged over fifty are not even familiar with mobile apps.”* (Health worker 06, Doctor)

One health worker noted that smoking cessation apps may not be effective if they are not intuitive and easy to use. This finding echoed the findings of the two systematic reviews, which found that ease of use is an important attribute of smoking cessation apps (Chapters 4 and 5).

*“Smoking cessation apps are not very easy and intuitive to use sometimes, so some patients are confused to use them... Compared with a simple smoking cessation booklet, apps are complex interventions.”* (Health worker 01, Nurse)

Another health worker’s concern was the sustainability of smoking cessation apps. One health worker shared the experience of being part of a research team developing a smoking cessation app. They mentioned that the smoking cessation app designed by the research team was not sustainable due to the lack of funding and human resources, so the smokers included in the research project relapsed but could not get support from the intervention or the research team anymore.

*“We designed a smoking cessation app in a funded project and provided free follow-ups and pulmonary function checks for smokers included in the research project, but you know... due to the limited funding and resources, the intervention was not sustainable when the project finished.”* (Health worker 01, Nurse)

The sustainability of smoking cessation apps is crucial because smoking cessation requires long-term persistence (Livingstone-Banks et al., 2019). Health workers

believed that smokers could still have cravings even when physical withdrawal symptoms have gone since smoking has been integral to daily life. To successfully stop smoking, smokers need to change their previous smoking habits and form new behavioural patterns, such as recording the number of abstinence days within apps. Therefore, smoking cessation apps must be sustainable to operate, providing ongoing assistance to help smokers achieve their quitting goals.

*“Even when doctors prescribed some smoking cessation medication to them to overcome the withdrawal symptoms, they still have cravings because smoking is an acquired habit...It takes a long time to recover from tobacco addiction, so smoking cessation apps must provide sustainable support.”* (Health worker 01, Nurse)

*“During the use of smoking cessation apps, keeping using the app to record progress could become a new habit, which could promote smoking cessation.”*  
(Health worker 02, Smoking cessation clinic staff)

This health worker suggested that generating income through advertisements could be one solution for the sustainability of smoking cessation apps. However, it was emphasised that the advertisements should be relevant to smoking cessation. Otherwise, they can have a negative impact on user experience.

*“Advertisements are the funding sources of smoking cessation apps as long as they are relevant to smoking cessation. Irrelevant advertisements may cause users to question the app’s professionalism and credibility, especially in health-related apps.”*  
(Health worker 01, Nurse)

Overall, health workers acknowledged the portability and convenience of smoking cessation apps. However, they expressed concerns about the applicability, ease of use, and sustainability. Inputting relevant advertisements could be beneficial to provide sustainable funding without sacrificing user experience.

## 6.7 Four initial programme theories

Based on the findings of two systematic reviews and the health worker interview findings, different contexts, mechanisms, and outcomes were identified, using abductive thinking to formulate IPTs. Following the two systematic reviews and interviews with six Chinese health workers, four IPTs were developed with their corresponding CMOCs (Table 6.3). These IPTs are related to 1) boosting motivation and self-efficacy, 2) social support, 3) relapse prevention skills, and 4) sustained user engagement.

Programme theory	Contexts	Mechanisms	Outcomes
1. boosting motivation and self-efficacy	Smokers are not motivated to stop smoking or lack confidence in successful smoking cessation	<p>M1: Engage with app features that provide visualisation of quitting progress, health benefits, financial savings, and virtual rewards and smokers gain a sense of achievement</p> <p>M2: Engage with app features that educate them on the benefits of smoking cessation and the risks of smoking. Smokers know smoking cessation is good for themselves</p>	<p>O1: Boosted motivation to quit smoking and self-efficacy increases</p> <p>O2: Boosted motivation to quit smoking</p>
2. Social support	Smokers lack social support and seek it from other quitting peers within apps	<p>M1: Engage with the social support features within apps to connect with other quitters and feel being understood</p> <p>M2: Engage with the social support features within apps and learn experience from successful quitters and build capacity</p>	<p>O1: Smokers feel being supported in smoking cessation</p> <p>O2: Smokers become more confident to stop smoking</p>

		M3: Engage with the social support features within apps and learn from relapsed smokers and become vigilant to high-risk situations	O3: Reduced relapse
3. Relapse prevention	Smokers find it difficult to resist cravings	M1: Engage with features to find tips to cope with or distract them from cravings and become more skilled in resisting cravings  M2: Engage with app features to record their cravings and become clearer on their craving patterns, so smokers become more prepared to high-risk situations	O1: Smokers become more confident to resist cravings  O2: Reduced craving triggers
4. Sustained user engagement	Apps consider user privacy and security, employ an easy and intuitive operation system, maximise personalisation and interactivity, provide multiple modalities, and keep the apps highly relevant to smoking cessation to ensure sustained user engagement	M1: Users find the app more appealing and reliable and enjoy using the app	O1: Sustained user engagement

Table 6.3 IPTs in CMOCs

### 6.7.1 IPT 1: Boosting motivation and self-efficacy

The findings of the 2<sup>nd</sup> systematic review indicated that increased motivation and self-efficacy are two intended outcomes of using smoking cessation apps. According

to the 1<sup>st</sup> systematic review results, smokers preferred to receive positive reinforcements over negative ones. App features displaying quitting progress, such as abstinence days, and benefits of smoking cessation, such as health gains, financial savings, and virtual rewards, can be effective in boosting smokers' motivation and self-efficacy. This finding was complemented by the interview data, which showed that lacking knowledge of the risks of smoking and the benefits of smoking cessation will demotivate smokers from stopping smoking.

This IPT was formulated using the 'if...then...because' statement:

“If smokers are not motivated to stop smoking or lack confidence to stop smoking (C), they are likely to engage with app features that provide visualisation of quitting progress, health benefits, financial savings, virtual rewards and educate them the benefits of smoking cessation and the risks of smoking (M), then smokers will be more motivated to stop smoking and more confident to stop smoking (O) because they gain a sense of achievements and understand smoking cessation is beneficial to them (M).”

#### 6.7.2 IPT 2: social support

Based on the findings of the 1<sup>st</sup> systematic review and interviews with health workers, providing social support feature is important because it enables smokers to connect with other quitting peers who can easily understand and empathise with them. In addition, interview findings also indicated another potential mechanism, which was that smokers learn from successful and failed quitters.

This IPT was formulated using the 'if...then...because' statement:

If smokers lack social support and seek it from other quitting peers (C), they will engage with the social support features within apps to connect with other quitters and learn from both successful and failed quitters (M), then they will become more confident in smoking cessation and feel supported, which may reduce the risk of relapsing (O) because they build capacity and become vigilant to relapses (M).

### 6.7.3 IPT 3: relapse prevention

According to the findings of the 1<sup>st</sup> systematic review, the relevant app features to prevent relapse could be the education, tracking, and distraction features. The education feature provides practical skills to cope with cravings. The distraction feature provides various tips to distract smokers from cravings. Furthermore, the tracking feature enables smokers to record their cravings within apps so smokers will be more aware of their craving patterns. The interview data with health workers indicated that one of the barriers to smoking cessation is that Chinese smokers experience negative emotions.

This IPT was formulated using the 'if...then...because' statement:

If smokers find it difficult to resist cravings (C), they will engage with smoking cessation apps to find tips to cope with or distract them from cravings and record their cravings (M), then smokers could be more confident in preventing relapse and craving triggers will reduce (O) because they become more skilled in managing cravings and more aware of their craving patterns (M).

### 6.7.4 IPT 4: sustained user engagement

The findings of the 2<sup>nd</sup> systematic review indicated that sustained user engagement is an important indicator of the success of smoking cessation apps. Therefore, sustained user engagement is one of the intended outcomes when engaging with smoking cessation apps. The 1<sup>st</sup> systematic review found smokers expected smoking cessation apps to be easy to use, provide personalised support and multiple modalities, increase interactivity, and consider user privacy and security. In addition, health worker interview data also indicates the importance of keeping the apps easy to use and making apps highly relevant to smoking cessation.

This IPT was formulated using the 'if...then...because' statement:

If smoking cessation apps consider user privacy and security, employ an easy and intuitive operation system, maximise personalisation and interactivity, provide

multiple modalities, and keep apps highly relevant to smoking cessation(C), then sustained user engagement will be achieved (O), because users find the app more appealing and reliable and enjoy using the app (M).

## 6.8 Summary

This chapter first presents findings from the interviews with Chinese health workers. Overall, Chinese smokers face barriers when they want to stop smoking due to a lack of knowledge, lack of motivation, negative emotions, and the specific smoking culture in China. In terms of the perceived usefulness of smoking cessation apps, health workers believed that these apps could provide positive psychological hints and social support, which was consistent with the findings of two systematic reviews. Regarding the effectiveness of smoking cessation, health workers were sceptical about it due to concerns about ease of use and sustainability. The interview findings were used to complement the two systematic reviews, and finally, four IPTs were formulated to drive the following stages of the research. In the following chapters, I will present how the IPTs were tested and refined using interviews with smokers.

## CHAPTER SEVEN: Testing of programme theories

### 7.1 Introduction

This chapter presents the qualitative data analysis findings of smoker interviews that were used to test the IPTs. Testing at this stage involved interrogating the data based on the contexts, mechanisms and outcomes within IPTs from the perspective of smokers who have used smoking cessation apps to support their smoking cessation journey. The findings presented in this chapter will further be refined into CMOCs to enhance the understanding of how smoking cessation apps work and presented in Chapter 8.

### 7.2 Participants characteristics

Semi-structured interviews were conducted with 24 Chinese smokers who have used smoking cessation apps before. The recruitment of smokers was via social media platforms and the interviews were conducted using WeChat. Table 7.1 shows participants' characteristics, including age, gender, education level, occupation, and the app name. The interview duration ranged from 40 to 80 minutes.

No.	Age	Gender	Education level	Occupation	App names
1	36	Male	Bachelor's degree	Computer science engineer	Smoking Cessation Army
2	31	Male	College diploma	Self-employed	Smoking Cessation Army
3	21	Male	Bachelor's degree	Student (software engineering)	iHabit
4	25	Male	Bachelor's degree	Travel consultant	3 Krystal Smoking Cessation
5	23	Female	College diploma	Sales	Smoking Cessation Army
6	27	Male	Bachelor's degree	Automotive engineering	Smoking Cessation Army
7	28	Male	Master's degree	Teacher	Smoking Cessation Army
8	39	Female	Bachelor's degree	Sales	Smoking Cessation Army
9	45	Male	Master's degree	Civil servant	Smoking Cessation Army
10	26	Male	College diploma	Graphic designer	Quit Smoking Tool
11	29	Male	Bachelor's degree	Finance	Smoking Cessation Army
12	27	Female	College diploma	Sales	Smoking Cessation Army
13	24	Male	High school	Sales	Smoking Cessation Army
14	35	Female	College diploma	Civil servant	Smoking Cessation Army
15	33	Male	Bachelor's degree	Self-employed	Smoking Cessation Army

16	25	Female	Bachelor's degree	Electrical engineer	Smoking Cessation Army
17	30	Male	Master's degree	Civil servant	Smoking Cessation Army
18	29	Male	College diploma	User interface designer	Smoking Cessation Army
19	25	Male	Bachelor's degree	Fitness coach	Smoking Cessation Expert
20	27	Male	College diploma	Marine engineering	No Tobacco
21	25	Female	Bachelor's degree	Sales	Quit Smoking
22	24	Male	Bachelor's degree	Web operations specialist	Smoking Cessation Army
23	33	Male	College diploma	Sales	Smoking Cessation Army
24	25	Male	High school	Photographer	No Tobacco

Table 7.1 Participants characteristics (smokers)

### 7.3 Themes

Themes were developed using the hybrid approach of inductive and deductive coding (Chapter 3). Both deductive themes and inductive themes were identified. Ten major themes emerged from the interview data, and eight of them were identified deductively based on findings of previous chapters (Chapters 4, 5, 6). Notably, some codes identified inductively were integrated into related deductive themes, which were then regarded as derived deductively. For example, when the subtheme 'extrinsic motivation' was identified from interview data, it was categorised into the broader theme 'motivations to smoking cessation'. Since 'motivations to smoking cessation' was a deductively identified theme, all its subthemes were regarded as being identified deductively. All identified themes and sub-themes are shown in Table 7.2.

Selected quotes were used to illustrate themes. Each quote is followed in parentheses by the interviewee's gender and the smoking cessation app they used. Gender reflects the impact of diverse social norms and expectations on smoking as a gender-differentiated social behaviour. App names are included to account for the varied functions and characteristics of the smoking cessation apps utilised by the interviewees.

Themes	Sub-themes	Approach
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1. Motivations to stop smoking	<ul style="list-style-type: none"> <li>• 1.1 Extrinsic motivation</li> <li>• 1.2 Intrinsic motivation</li> <li>• 1.3 Transformation from extrinsic motivation to intrinsic motivation</li> </ul>	Deductive
2. Perceived usefulness		Inductive
3. Self-efficacy		Deductive
4. Social isolation	<ul style="list-style-type: none"> <li>• 4.1 Social stigma</li> <li>• 4.2 Lack of support from people in real life</li> </ul>	Deductive
5. Social support	<ul style="list-style-type: none"> <li>• 5.1 Emotional support</li> <li>• 5.2 Informational support</li> <li>• 5.3 Sense of healthy competition</li> </ul>	Deductive
6. Disengagement with social functions		Inductive
7. Education on withdrawal symptoms		Deductive
8. Withdrawal symptoms recording		Deductive
9. Usability	<ul style="list-style-type: none"> <li>• 9.1 Ease of use</li> <li>• 9.2 Multiple modalities</li> <li>• 9.3 Visual design</li> </ul>	Deductive
10. User experience	<ul style="list-style-type: none"> <li>• 10.1 User privacy</li> <li>• 10.2 Record keeping</li> <li>• 10.3 Advertising and membership fees</li> <li>• 10.4 Gamification</li> <li>• 10.5 Personalisation</li> </ul>	Deductive

Table 7.2 Themes and subthemes (smoker interviews)

#### 7.4 Theme 1: Motivations to stop smoking

Motivations to stop smoking relate to both the driving force that pushes smokers to change their smoking behaviour and the strengthening of their desire to do so. It can be intrinsic or extrinsic, which reflects the origins of the desire to change smoking

behaviour (Morris et al., 2022). Intrinsic motivation refers to the internal forces behind individuals' behaviours (Larson and Rusk, 2011), such as the consideration of health. Conversely, extrinsic motivation comes from external factors, such as rewards, short-term goals, etc. (Morris et al., 2022).

In this study, smoking cessation apps could employ different strategies to improve extrinsic motivation. However, interview data showed that extrinsic motivation provided by apps may decrease with time. Therefore, apps should also employ strategies to enhance smokers' health awareness, understanding of the risks of smoking, and desire for a smoke-free life to promote their intrinsic motivation. In the short term, extrinsic motivation can enhance user engagement levels to help smokers stop smoking, but in the long term, increasing intrinsic motivation is the key factor for sustained smoking cessation behaviour (Deci and Ryan, 2012a).

Interview data showed that having enough motivation, intrinsically or extrinsically, is the prerequisite for successful smoking cessation and relapse prevention because motivation directly affects smokers' decision-making and behaviours. Therefore, emphasising and nurturing sufficient motivation, intrinsically or extrinsically, to quit smoking is highly important for smokers to make the decision to start smoking cessation.

An interviewee mentioned that before making the decision to quit smoking, there must be enough motivation to drive them to quit. He held the belief that smoking cessation is an active undertaking that will not happen naturally but has to be driven by some motivations.

*"I feel that quitting smoking is not something I want to do without any reasons. I think it should be active action out of some motivations...I believed that smoking has no benefits for me and it harmed my health. This was why I wanted to quit."* (Interviewee 22, Male, Smoking Cessation Army)

Before smokers make the decision to quit smoking, they must have some initial motivation that prompts them to change their smoking behaviour, regardless of the withdrawal symptoms (Buczowski et al., 2014). Without these initial motivations, it is

difficult for smokers even to consider quitting (Hunt, 2017). Before deciding to quit smoking, motivation is crucial for determining whether to quit and whether to maintain abstinence. When motivation is strong and sufficient, the scales tip towards the benefits of quitting, enabling them to make a determined decision to quit and maintain abstinence (Buczowski et al., 2014).

*“We don't know when cravings will strike, so it's helpful to read articles on the benefits of quitting smoking. These articles can strengthen motivations by explaining how life improves after quitting smoking. They help us build the determination to maintain abstinence. For example, thinking about how our health will improve after quitting or understanding the negative consequences of smoking can motivate us to stay committed.”* (Interviewee 24, Male, No Tobacco)

Interview data showed that smoking cessation apps can serve as supplementary tools to assist motivated smokers in quitting. The relationship between app usage and quitting smoking is that when smokers are motivated to quit, they choose to use the app, and subsequently, the app can strategically assist them in quitting (Kruse, 2019). Conversely, smokers will not effectively use the app if they are not motivated to stop smoking.

*“It's better to start quitting when you are motivated to quit by yourself. Then, you make a firm decision and combine it with the methods from these apps to quit smoking.”* (Interviewee 11, Male, Smoking Cessation Army)

*“The smoking cessation app primarily serves as a supplementary tool. Using this app alone won't make you want to quit smoking. It's not this causal relationship. It is because I want to quit smoking that's why I choose to use this app.”* (Interviewee 15, Male, Smoking Cessation Army)

On the contrary, if a smoker is not motivated to stop smoking but still download and use the app, their engagement could be counterproductive (Smith et al., 2017). An interviewee emphasised that apps would have a counterproductive effect on smokers who lacked sufficient motivation to stop smoking or decided to quit due to external pressures. Therefore, being motivated to stop smoking is one of the

prerequisites of using the app and effective user engagement. However, smokers can still download the app out of external pressure, for example, pushed by their family members. In this case, user engagement with apps could be counterproductive. For example, if a smoker is not motivated to quit or decides to quit under pressure, some app functions, such as sending repeated reminders, may cause them annoyance, thus affecting the outcomes of their smoking cessation efforts.

*“Indeed, for a smoker who doesn’t seem very motivated to quit and may have hesitations or is being pressured by family and friends to quit, it’s a different situation. They may lack self-discipline and may inherently resist the idea of quitting. They might feel unsure of their ability to succeed and may even find quitting unpleasant. Constant reminders to quit can be irritating.”* (Interviewee 16, Female, Smoking Cessation Army)

Given the importance of motivation of smokers in quitting smoking, smoking cessation apps as a supplementary tool, can nurture both intrinsic and extrinsic motivation of smokers to maintain abstinence. However, which app functions smokers will be interested in and engaged in depends on their initial motivations. For example, smokers who decide to stop smoking out of health reasons may engage more with the health recovery overview. Meanwhile, smokers who decide to stop smoking out for financial reasons may care about the financial saving function. When app features closely match user needs, their motivations will increase.

*“I feel like... app features should align with what users want or care about. For example. I remember the app told me that smoking accelerated the aging of the skin, which deeply affected me because I care much about my appearance. I used to think that smoking only harmed the lungs or the respiratory tract.”* (Interviewee 16, Female, Smoking Cessation Army)

Previous literature indicated that self-health is the most frequently mentioned motivation to smoking cessation (Martins et al., 2021). Providing information that highlights the health benefits of smoking cessation also aligns with smokers’ needs (Bendotti et al., 2022). The current study also found that among the motivations for

smoking cessation, improving health conditions is the motivation mentioned by all interviewees.

*"The motivation to quit smoking... I felt I cannot continue smoking like this anymore... it's bad for my health... the motivation related to physical health is quite apparent."*

(Interviewee 15, Male, Smoking Cessation Army)

Another motivation mentioned by interviewees was financial incentives, such as saving money to buy something important to them. A financial incentive is effective in boosting general smokers' smoking cessation motivation (Sigmon and Patrick, 2012). An interviewee mentioned that he decided to quit smoking to save some unnecessary costs. Thus, he appreciated the app function that showed how much money had been saved.

*"I just want to cut some unnecessary expenses. I spend money on daily meals, transportation, and housing, but smoking leads to some extra costs, so I want to avoid those expenses, which is why I want to quit smoking... The app displays how much money I've saved and how long I've been smoke-free... When I see that I've saved a significant amount of money, I feel quite satisfied that I'm not wasting money on smoking."* (Interviewee 10, Male, Quit Smoking Tool)

However, showing financial savings within an app feature is not motivating for everyone, especially those who did not stop smoking for financial reasons. An interviewee denied getting motivated by viewing the saved money because the cost of cigarettes is not an issue for her, and she questioned whether the financial saving function is vital.

*"Because the brand of cigarettes I smoke, Yuxi, is not expensive – it costs 23 yuan per pack, and I don't smoke a lot so the money-saving aspect of the app doesn't feel as satisfying... if the cigarettes I smoke are relatively expensive, and I smoke one or two packs a day, the money-saving will be significant in this regard."* (Interviewee 8, Female, Smoking Cessation Army)

Overall, motivated smokers can effectively engage with smoking cessation apps. However, whether a specific app feature will be effective depends on its alignment with user needs.

#### 7.4.1 Subtheme 1.1 Extrinsic motivation

Smoking cessation apps employ various strategies to enhance smokers' extrinsic motivations. For example, most apps include a feature that allows users to 'check in' daily to log their smoke-free days. Based on the recorded days of abstinence, the app displays their health recovery status, such as blood oxygen levels, and shows the financial savings achieved. In addition, the Smoking Cessation Army app employs a specific military rank system to motivate smokers to achieve higher ranks through checking in more abstinence days. This rank system serves as a reward mechanism for the smokers' achievements of maintaining abstinence, thus reinforcing their motivation externally. The daily check-in function and the military rank system were appreciated by most interviewees, motivating them to achieve the goal of getting promoted in the military rank system.

*“Another motivating aspect of the app is the military rank system it employs. As time progresses, my rank increases, and currently, I hold the rank of a commander. This sense of achievement and progress further motivates me to keep abstinence.”*

(Interviewee 13, Male, Smoking Cessation Army)

*“Sometimes, it's actually just about giving me a sense of achievement. I feel I've done a great job because I can quit smoking. Having checked-in for so many days, it's all about having this mindset.”* (Interviewee 7, Male, Smoking Cessation Army)

Another extrinsic motivation that apps can provide through viewing abstinence days is the previous efforts that have been put into smoking cessation. Viewing the abstinence days also reminds smokers of how much effort they have made, so they are reluctant to give up the achievements.

*“Once you start using the app, if you relapse, you’ll lose all the progress you’ve made up to that point, and that would be a shame... making you think twice about the cost of relapse.”* (Interviewee 11, Male, Smoking Cessation Army)

#### 7.4.2 Subtheme 1.2 Intrinsic motivation

Although apps help smokers quit smoking by providing extrinsic motivations, such as recording abstinence days, displaying health recovery status, showing money saved, etc., the effect of these external incentives only exists while the smoker is utilising the app. Once a smoker decides to stop using the app, the effects of external motivational factors diminish (Deci and Ryan, 2012a, Deci and Ryan, 2012b). Therefore, it is crucial that apps employ strategies or features to nurture smokers’ intrinsic motivation for them to understand that it is in their interest to quit smoking. When smokers are intrinsically motivated to quit smoking, they are more likely to keep their abstinent lifestyle even when they stop using smoking cessation apps.

As mentioned previously, intrinsic motivation arises when smokers realise that smoking cessation has profound benefits for themselves, allowing them to stay abstinent even in the absence of external rewards (Larson and Rusk, 2011). Most smoking cessation apps primarily enhance intrinsic motivation by fostering health awareness (Seo et al., 2022). For example, educating smokers about the specific risks of smoking and the benefits of smoking cessation. The process of gaining a deep understanding of the risks of smoking and recognition of the benefits of smoking cessation can promote a strong intrinsic motivation. Protection motivation theory (PMT) posits that individuals’ behaviours protecting themselves from harmful behaviours, such as smoking, are influenced by the severity of the harmful behaviour and the efficacy of the preventive behaviour (Rogers, 1975). In this study, educating smokers on the risks of smoking and the benefits of smoking cessation aligns with PMT by increasing the perceived severity of smoking and the efficacy of smoking cessation.

To boost intrinsic motivation, smoking cessation apps can provide both positive stimuli to encourage smokers to keep abstinence, such as showing the benefits of smoking cessation, and negative stimuli, such as educating them about the negative

effects of smoking, such as the possibility of developing diseases. Research shows that smokers are more likely to be motivated by positive stimuli (Edwards et al., 2018, Zhang et al., 2023), which resonates with the findings of the current study.

This study found that smokers are often benefit-oriented in the context of smoking cessation. Compared with the risks of smoking, which may not be personally experienced by smokers, the benefits of smoking cessation can be displayed explicitly within apps to make smokers more aware of these benefits. When apps provide information on the positive changes happening in their bodies, smokers tend to believe these positive changes.

*“I believe in the app's indication of how much longer life can be extended, and I genuinely believe that my life can be prolonged because it's widely stated online.”*  
(Interviewee 19, Male, Smoking Cessation Expert)

*“It (health recovery overview) will have an average value, which is not accurate, to be honest. But it's quite enjoyable just looking at it, very exciting.”* (Interviewee 8, Female, Smoking Cessation Army)

However, compared with positive stimuli, providing negative stimuli, such as educating them on the risks of smoking, is not so effective. First of all, most smokers already have a basic understanding of the harms of smoking, but the addictive nature of nicotine, the pleasure derived from smoking, or the social convenience smoking brings still makes it hard to stop smoking (Zheng et al., 2013). Being aware of the negative effects of smoking may not necessarily trigger the desire to quit (Lin and Chang, 2021). This could be due to the addictive and habitual nature of smoking forming a physiological and psychological connection (Marlatt and Gordon, 1985).

Furthermore, interview data showed that when cravings come, smokers may be more concerned about the distress of losing the companionship of cigarettes rather than the uncertain harmful effects of smoking. Therefore, emphasising negative information which they already know may not be a strong stimulus. While smokers tend to believe positive changes happened to them due to smoking cessation, they

may deny the severity of smoking and feel they are the lucky ones to escape and that adverse consequences will not happen (Barnett et al., 2022).

*“No matter how terrifying the consequences of smoking are, they can’t compare to the terror of being without cigarettes during moments of craving. That’s why it’s important to discuss the benefits of quitting smoking... I derive a lot of happiness and joy from smoking. Why quit smoking? I have not experienced health issues from smoking, and the absence of cigarettes would make me feel worse, right?”*

(Interviewee 2, Male, Smoking Cessation Army)

From the perspective of smokers, it is common knowledge that smoking is harmful to health, but many people may not fully understand its severity unless they have personally experienced it. However, the benefits of quitting smoking can be instantly visible and evident. Although making smokers personally feel the real changes in their bodies requires a considerably long period, apps can display the health benefits of smoking cessation that motivate smokers to stay abstinent.

*“Another app feature shows my health recovery status. For example, the possibility of getting lung cancer recovered to 30% or 50% of normal people...It is probably these stuff, that enable me to view the benefits of smoking cessation explicitly.”*

(Interviewee 1, Male, Smoking Cessation Army)

Smokers hope apps can bring their minds to positive aspects by providing more positive information. When a smoking cessation app displays horrifying images to demonstrate the dangers of smoking, it can induce a sense of fear. This fear might motivate smokers to take action to quit smoking to avoid the consequences of smoking. However, when the fear is too intense, smokers may associate smoking cessation with strong negative emotions, potentially increasing their resistance to smoking cessation because they do not want to experience these negative feelings. App developers should employ the negative stimuli strategy with caution to strike a balance to motivate smokers but not induce strong negative emotions. A more effective approach might be to employ positive stimuli to help smokers understand the benefits of quitting smoking, thereby motivating them to quit smoking and maintaining a positive mindset.

*“If the app displays horrifying images to make me feel like if I do not quit smoking, I can avoid confronting these terrifying things. I have to face these negative things every day because of smoking cessation, it would make quitting even more difficult.”*  
(Interviewee 16, Female, Smoking Cessation Army)

#### 7.4.3 Subtheme 1.3 Transformation from extrinsic motivation to intrinsic motivation

Aside from educating smokers on the risks of smoking and the benefits of smoking cessation, smoking cessation apps can also increase intrinsic motivation unconsciously because extrinsic motivation can transform into intrinsic motivation (Deci and Ryan, 2012b). Strategies to boost extrinsic motivations, such as displaying abstinence days, rank upgrade, financial savings, rewards, etc., makes smokers feel their efforts have paid off and they are making progress in their smoking cessation journey. For example, the abstinence days recording feature and the rank system serve as extrinsic motivations when smokers first use smoking cessation apps. However, the rank advancements and quitting smoking achievements can serve as the recognition of the smokers' efforts to quit over time. When smokers start to realise the value and significance of quitting smoking through these external rewards, their intrinsic motivation will also increase.

*“I feel like I'm quitting smoking for my health. It (showing the abstinence days) reminds me that my body is getting better and better makes me so happy.”*  
(Interviewee 14, Female, Smoking Cessation Army)

For example, the *Smoking Cessation Army* has gained the favour of many smokers through its unique rank system. The military ranks of users change with the increase in the number of smoke-free days, progressing step by step from a soldier to a commander, and if smokers' ranks get promoted, they feel their efforts are recognised and paid off. Thus, the extrinsic motivation for getting promoted in the rank system can transition into intrinsic motivation to maintain smoking cessation over a prolonged duration.

*"It can be used to check in abstinence days. Viewing these numbers increase puts you in a better mood... From the soldier to the commander, there's still a sense of achievement. I felt smoking cessation is meaningful, so I just wanted to keep this smoke-free lifestyle."* (Interviewee 9, Male, Smoking Cessation Army)

Overall, for smokers to consider utilising smoking cessation apps as a supplementary tool to quit smoking, they must first be motivated to stop smoking. To sustain smoking cessation efforts, apps should focus on cultivating intrinsic motivation by educating smokers on the health risks associated with smoking and the benefits of smoking cessation to nurture a deep and strong desire to stop smoking, independent of external incentives.

Extrinsic motivation can provide clear indicators of quitting progress, such as the number of abstinence days and the money saved. This makes smokers feel that quitting smoking is meaningful and that their efforts have paid off. According to self-determination theory (SDT), when extrinsic motivation is integrated into an individual's internal values, it can be transformed into intrinsic motivation (Deci and Ryan, 2013).

## 7.5 Theme 2: Perceived usefulness

The extent to which smokers engage with a smoking cessation app depends not only on their motivation level and whether the app features meet unique user needs but also on the app's perceived usefulness. If a smoker firmly believes that quitting smoking is entirely a matter of personal effort and is skeptical about the effectiveness of external tools, including smoking cessation apps, then apps may not be effective for them.

Some interviewees believed that quitting smoking is something they could achieve through their efforts, which meant these smokers believed that they could quit smoking relying on their determination and power, without depending on external assistance. Even if such smokers download the smoking cessation app, their engagement with the app might be minimal, for example, just using apps to track the abstinent days rather than engaging with other app features in their smoking

cessation journey. This means that even if smokers are motivated to stop smoking, smoking cessation apps cannot achieve their intended effects if the perceived usefulness is low.

*“Smoking cessation mainly relies on personal determination and persistence. This smoking cessation app, I feel that it just serves as a tool to record abstinence days.”*  
(Interviewee 15, Male, Smoking Cessation Army)

Perceived usefulness is crucial for the app to achieve its intended effects. If users believe that the app can provide them with the necessary support and resources to help them quit smoking, they are more likely to actively engage with the app, thereby allowing it to have the greatest impact. Conversely, smokers who hold the belief that the success of smoking cessation solely depends on their efforts and doubt the effects of smoking cessation apps think some user engagement could have counterproductive effects, for example, triggering anxiety or cravings. For example, one interviewee who doubted the usefulness of smoking cessation apps worried that frequent engagement, such as daily check-ins, might reinforce their thoughts associated with smoking. She believed that the best way to quit smoking is to minimise attention related to quitting as much as possible. Thus, she only used the app to check how much health had been recovered and did not use other app features.

*“The existence of a smoking cessation app is a terrible thing because quitting smoking is about weakening the concept of time, yet it keeps reminding you how long you have quit...If the app keeps reminding me of the number of days of smoking cessation, it makes me feel anxious, you know? Because it's a reminder that I've gone 60 days without nicotine, and it can be uncomfortable.”* (Interviewee 14, Female, Smoking Cessation Army)

Overall, the perceived usefulness of smoking cessation apps is another prerequisite that makes an app useful for motivated smokers. Users may engage with very limited app features if they do not believe apps could be an effective tool to help them stop smoking. For smokers who do not recognise smoking cessation apps as

useful tools, user engagement could have counterproductive effects, inadvertently triggering cravings.

### 7.6 Theme 3: Self-efficacy

Self-efficacy refers to an individual's belief in his ability to achieve specific goals, reflecting his confidence in his ability to control his behaviours (Bandura, 1977). In this study, self-efficacy indicates smokers' beliefs in their capabilities to resist cravings and maintain abstinent status. Self-efficacy is an effective predictor of smokers' smoking cessation behaviour (Gwaltney et al., 2009).

Self-efficacy influences the smoking cessation goals set by smokers and their ability to adhere to achieving these goals. When their self-efficacy is higher, they are likely to set higher goals and firmly believe that they can achieve these goals. For example, as the abstinence days increase, smokers will become more convinced that they can maintain a smoke-free state. Their expectation for themselves is to become a 'non-smoker', not just a 'quitter'. The transformation from a "quitter" to a "non-smoker" is not just about smoking status change but also a change of self-identity, which comes with increased confidence in their self-control abilities, thereby enhancing self-efficacy.

*"I'm not thinking about whether I can stay abstinence. I am a non-smoker now. I'm not in the process of quitting smoking."* (Interviewee 22, Male, Smoking Cessation Army)

Smoking cessation apps employ a lot of strategies to make users believe they are capable of succeeding in smoking cessation, including recording quitting progress and showing them the benefits they have accumulated since their smoking cessation journey started. Enhanced self-efficacy as a common outcome after successfully quitting smoking for a period demonstrates that smokers' confidence in smoking cessation can improve over time. For example, some smokers mentioned viewing the achievements made them more confident about achieving smoking cessation.

*"Having those real records and realising that I've managed to be abstinent for such a long time gives me the belief that I can continue to do so in the future."* (Interviewee 10, Male, Quit Smoking Tool)

Quitting smoking is a challenging task for smokers due to its addictive and habitual nature. Smokers who are just starting to quit smoking may initially perceive smoking cessation as an extremely tough task and may doubt their ability to successfully quit. However, when they are encouraged by positive stimuli provided by apps, they will genuinely affirm their determination and capability of smoking cessation. Progress and achievements will boost their self-efficacy and help them face the smoke-free lifestyle with greater confidence.

*"When I see the number of abstinence days, I will continue to cheer myself up and feel very proud of myself. I believe I have achieved something I once thought I couldn't, and now I have done it. I will also praise myself for this achievement."* (Interviewee 24, Male, No Tobacco)

*"This smoking cessation app can boost my confidence by helping me realise that I'm making continuous progress and getting closer to success. It gives me the confidence to maintain abstinence."* (Interviewee 16, Female, Smoking Cessation Army)

Essentially, when smokers start on their journey to stop smoking, they are often unsure about their ability to overcome challenges. However, as abstinence days accumulate, which is often shown within apps, their self-efficacy strengthens. As explained in the theme of 'extrinsic motivation', specific app features that enhance extrinsic motivation are usually only effective in the initial stages of app usage. However, the key for an app to help smokers quit in the long term lies in increasing the smoker's intrinsic motivation and continuously enhancing self-efficacy.

*"I suddenly realised that I have already been smoke-free for a whole year. It made me feel that smoking is not necessary, and my life is not adversely affected by not smoking."* (Interviewee 21, Female, Quit Smoking)

As self-efficacy increases, smokers become more confident in their abilities to continue smoking cessation and rely less on apps. Interviewees mentioned that apps are no longer needed when they believe in their capabilities to cope with challenges in smoking cessation. This finding resonates with the previous finding in the 'perceived usefulness' theme that when smokers strongly believe that smoking can be achieved through their efforts, they tend to decrease engagement with app features.

*"Maybe after some time, I will definitely uninstall the app because I feel like I won't need it anymore."* (Interviewee 15, Male, Smoking Cessation Army)

*"I stopped checking in a long time ago. From the six months of smoking cessation, I no longer felt the need to do so. I thought checking in was wasting time, and now I don't need the app to tell me how many days I've been smoke-free."* (Interviewee 22, Male, Smoking Cessation Army)

In summary, for smokers, each day of successfully maintaining abstinence represents a small victory, and the accumulation of these victories can significantly boost their self-efficacy. Through the use of smoking cessation apps, they see their quitting progress and all the benefits they have gained since smoking cessation, so they gradually become more confident in their capabilities in maintaining their smoke-free status, thereby enhancing their self-efficacy. With the accumulation of abstinence days, smokers' self-identify transitions from 'quitters' to 'non-smokers', showing extremely strong self-efficacy. User engagement with apps tends to decrease at this stage.

## 7.7 Theme 4: Social isolation

In the context of smoking cessation, social isolation refers to smokers having minimal social connections with others, leading to feelings of loneliness, which can negatively affect smokers' psychological or mental health (Philip et al., 2022). Social isolation is a common barrier faced by smokers, which can be an important contextual factor that smoking cessation apps can work through their interactivity

features. In this study, social isolation takes on different forms during the smoking cessation journey, including social stigma and lack of support from people in real life.

#### 7.7.1 Subtheme 4.1 Social stigma

Some smokers may feel isolated from people around them in real life because of negative judgments by society towards smoking (Philip et al., 2022). This discrimination against a specific group, such as smokers, can cause prejudice and exclusion, often referred to as social stigma (Triandafilidis et al., 2017). For example, social stigma can manifest as discrimination against smokers since they are perceived as lacking self-discipline, irresponsible, responsible for their bad health, lazy and so on (Link and Phelan, 2001, Stuber et al., 2009).

*“Some people would think of me as someone who does not take good care of my health, and also regard me as a person without self-control and lacking discipline.”*  
(Interviewee 13, Male, Smoking Cessation Army)

In traditional Chinese culture, female smoking is considered to go against social norms because smoking is generally viewed as a behaviour that does not align with traditional female roles, such as caring for children and doing housework (Xiao and Asadullah, 2020). The different social expectations and roles among males and females can make female smokers face greater pressure and moral condemnation from people around them (Davey and Zhao, 2020). When asked about the smoking-related social stigma interviewees have experienced, most of the negative comments came from female interviewees. For example, female smokers were often criticised for not conforming to social norms or were considered irresponsible towards their families.

*“Other people may have a bias towards me because of smoking. Although society is quite tolerant nowadays, they still tend to believe that it is not good for females to smoke.”* (Interviewee 5, Female, Smoking Cessation Army)

*“My parents actually are not happy with my smoking... Perhaps everyone would think that smoking is normal for males, but when it comes to females, they will have*

*some prejudices against them. My parents said smoking is irresponsible behaviour and will influence the fetus if I am pregnant in the future.”* (Interviewee 12, Female, Smoking Cessation Army)

#### 7.7.2 Subtheme 4.2 Lack of support from people in real life

When smokers decide to quit smoking, they may encounter a lack of support from non-smokers around them in real life. One of the reasons might be that non-smokers do not understand the addictive nature of smoking and how much determination and courage it takes to make the decision of smoking cessation (Cunningham, 2012). For non-smokers, stopping smoking is just a change in daily habits rather than a huge challenge involving a complex process of overcoming physiological and psychological dependency.

Another reason might be people around smokers may doubt their abilities to achieve smoking cessation due to their past failed experiences. Quitting smoking is a challenging task, and many smokers have attempted but relapsed in the end. If a smoker had previous unsuccessful attempts to quit smoking, people around them may doubt their ability and determination to quit.

*“When I first told my friends that I was going to quit smoking, they were doubtful about this decision. They would say, ‘Have you really decided to quit smoking? You are just making a joke, aren’t you?’”* (Interviewee 22, Male, Smoking Cessation Army)

At the same time, in real life, many smoking buddies may not consider quitting. Those who are in the precontemplation stage (Prochaska, 2008) might undermine the necessity of smoking cessation (Sun et al., 2007) or think that smoking cessation is an unrealistic goal to achieve.

*“Last time I quit smoking...I had quit for three months, and when I went out for drinks with friends, they offered me cigarettes. I refused, saying I had quit, but they didn’t believe me. They said, ‘You tried to quit smoking before, but you ended up smoking again.’”* (Interviewee 2, Male, Smoking Cessation Army)

In addition, the smoking culture in China may also hinder smokers who decide to stop smoking by facing opposition from the people around them. In China, sharing and gifting cigarettes are often considered as ways to enhance social relationships and friendships (Rich and Xiao, 2012). The interview data showed that once an individual within a social group decides to quit smoking, their smoking cessation decision may not be regarded seriously by their friends, who continue to offer them cigarettes.

*“When I first told my friends that I was going to quit smoking... they might ask why I suddenly decided to quit smoking, and in usual circumstances, they would continue to offer me cigarettes.” (Interviewee 22, Male, Smoking Cessation Army)*

What is even worse, since offering cigarettes in social situations is a common social gesture in China, smokers who are quitting might feel excluded from the social activity where social smoking takes place, which can exacerbate the feeling of isolation. When smokers strive to stop smoking, they may intentionally avoid social situations that involve social smoking. Those smokers may feel a sense of loneliness when they have stayed abstinent for an extended period because they may have lost the social connections established through smoking.

*“In a social situation where everyone is smoking except for me, they would ask me why I did not smoke and whether it is because I did not want to be with them.” (Interviewee 13, Male, Smoking Cessation Army)*

Additionally, smoking cessation can be an extremely lonely journey because of the high relapse rates. Even though smokers have quitting buddies to stop smoking together, they may experience a sense of loneliness when the quitting buddies have given up halfway.

*“Those who succeed in smoking cessation are actually quite lonely. Image that people who started quitting smoking with you have dropped out halfway because they relapsed, and in the end, you are left quitting on your own. It is actually quite*

*lonely, especially the quitting journey after three years, is very lonely.*" (Interviewee 1, Male, Smoking Cessation Army)

In summary, underestimating the difficulty of smoking cessation among non-smokers makes it hard for them to show empathy or understanding. In addition, other smokers in real life who have not considered smoking cessation may doubt the necessity of smoking cessation. The smoking culture in China also poses a considerable challenge for smokers to seek social support in real life. Having a social group where smokers can be understood and supported by peers is important to solve these problems in smoking cessation.

## 7.8 Theme 5: Social support

Smoking cessation is a challenging endeavour in which social support can increase the possibility of achieving goals (Johnson et al., 2009, Westmaas et al., 2010). If smokers experience stigma and social isolation in real life, social support features in apps may provide a platform for them to receive support, empathy and encouragement and share smoking cessation experiences. A social group with this positive atmosphere can be a safe place where users can communicate openly, whether they are experiencing success or failure in their smoking cessation journey, and without fear of judgment. The mutual support from other quitters helps smokers overcome challenges through difficult periods, as one participant explained below.

*"I think the app provided a platform full of positive feedback. To be honest, quitting smoking is not something that can be achieved easily on one's own... It's actually very difficult...With other users who were quitting together, encouraging each other, I think it can help get through this special period."* (Interviewee 12, Female, Smoking Cessation Army)

Three types of social support were identified in this study, namely emotional support, informational support from successful and failed quitters, and a sense of healthy competition.

### 7.8.1 Subtheme 5.1 Emotional support

Throughout the smoking cessation process, having like-minded peers showing empathy and understanding and having shared goals play vital roles (Qian et al., 2021). Engaging with a supportive social group can help overcome social isolation. Additionally, smokers attempting to quit may need to actively seek emotional support from people who can fully understand their challenges of quitting smoking. Once users download the app and join the social forum where many smokers are situated in similar quitting stages with similar smoking cessation goals, smokers start to feel that they are not fighting the smoking cessation battle alone.

*“I really appreciated the social function of this app. I thought if it weren’t for the support it has given to me, quitting smoking on my own would have been much more difficult. After downloading this app, I felt like I was not struggling alone. Instead, there were many like-minded people accompanying me to accomplish this significant task of quitting smoking.”* (Interviewee 12, Female, Smoking Cessation Army)

*“The meaning of the social function of the app is that users can quit smoking together so they will not feel lonely. They are not fighting alone.”* (Interviewee 17, Male, Smoking Cessation Army)

Since app users share similar quitting goals, they can receive empathy from their peers because they face similar challenges and difficulties, allowing them to relate and empathise with each other, which can be a significant emotional support. This emotional support may be lacking in their social circles in real life. The expression of empathy made smokers feel that their feelings were understood, therefore creating a powerful network of emotional support.

*“When I see the difficulties that other users encountered when quitting smoking, I can understand their feelings. It’s possible that the difficulties they talked about were the ones that I was experiencing myself.”* (Interviewee 18, Male, Smoking Cessation Army)

Compared with searching for quitting buddies in real life, smoking cessation apps can offer a broader support network (Granado-Font et al., 2018). When smokers need social support, active users in the app are often available to provide support. The constant availability of social support reduces the sense of loneliness in the journey of smoking cessation. Active users act as ‘fresh blood’ to help smokers feel that they are always accompanied by like-minded people who are making efforts towards the same goal. For example, the Smoking Cessation Army has a social function that puts users who start quitting smoking on the same day on a social forum called the *survivor tribe*. Grouping users who start quitting smoking on the same day has its unique advantage since they will have common milestones and withdrawal symptoms, which can increase resonance among smokers. Knowing that others are also going through difficult times and facing similar challenges can enhance smokers’ sense of belonging (Wunderlich, 2020).

*“There are many people in the tribe, and they encourage each other. Quitting smoking can be tough on your own, and having others to support you and receiving encouragement from them can be incredibly motivating.”* (Interviewee 2, Male, Smoking Cessation Army)

#### 7.8.2 Subtheme 5.2 Informational support

Another format of social support that smoking cessation apps provide is informational support from both successful and failed experiences of other app users. Interviewees reported that viewing others’ success in quitting smoking for a long time boosted their confidence to stop smoking. Successful quitters could act as role models by encouraging others to follow. In addition, they can also become vigilant to relapse when they read the failed experiences of others.

*“I think both successful and failed experiences have certain effects. When I saw others succeed, it made me think that I could succeed, too. When I saw someone fail because of relapse, I would also read what they said about the reasons for relapse, then alerted myself to avoid doing the same things.”* (Interviewee 10, Male, Quit Smoking Tool)

*“I mainly used the social forum to learn how successful quitters were able to keep abstinent for such a long time. When they share their experience in the group, I learned from them.”* (Interviewee 20, Male, No Tobacco)

Successful quitters may act as ‘missionaries’ in the social forum by believing that they have a responsibility to help other quitters overcome challenges by sharing their own experiences and tips. The sharing of successful quitters not only provides informational support to other smokers who are struggling to quit but also boosts the self-esteem of those successful quitters.

*“Successful quitters would also share some of the tips for smoking cessation within the social forum. At the same time, they would cheer us up to keep on going with smoking cessation. He has succeeded and he also wanted us to succeed as well.”* (Interviewee 13, Male, Smoking Cessation Army)

*“I also encouraged others to persist in quitting smoking and shared with them how I have managed to stay smoke-free until now. Some people, knowing that I have been smoke-free for so long, said I was an amazing person and they wanted to follow my steps. This feeling was fantastic as if I was doing something truly great.”* (Interviewee 18, Male, Smoking Cessation Expert)

The experience of those who have relapsed can also be used as a valuable resource to help smokers realise that relapse could be a normal part of breaking the addiction cycle and to remind quitters to remain vigilant of relapse even after a long period of abstinence. Smokers could avoid similar situations which trigger cravings and plan coping strategies in advance by analysing the relapse experiences of others. In addition, the regrets of those who have relapsed can also make other users more determined to maintain abstinence to avoid similar regrets.

*“Some people relapsed, and they reported why they relapsed this time in the social forum. I can feel their regrets and misery in their words and think that I would experience the same if I relapsed. This will make me more determined to stay abstinent.”* (Interviewee 4, Male, 3 Krystal Smoking Cessation)

### 7.8.3 Subtheme 5.3 Sense of healthy competition

In a group where everyone shared a collective endeavour, such as smoking cessation, it could automatically stimulate an underlying sense of competition (Isensee and Hanewinkel, 2012). It might be because people seek recognition in a socialised environment, and social forums provide a platform for them to share achievements. Comparing themselves to other smokers regarding their progress in quitting could provide them with a sense of achievement and increase their confidence. Furthermore, the existence of the underlying or latent competition motivated smokers to maintain the abstinence status to surpass other quitters. This was also a powerful motivator for them to maintain their smoking cessation endeavour.

*“It’s quite appealing that people who start their quit-smoking journey on the same day are all part of a social forum in the app...When you find the group size gradually decreasing, you will get a sense of achievement that you are doing better than other people.”* (Interviewee 6, Male, Smoking Cessation Army)

*“Some people relapsed, and it made me think if I can resist cravings while other people relapsed...I feel pretty good about myself for being able to persist quitting smoking.”* (Interviewee 12, Female, Smoking Cessation Army)

Overall, the social function of apps can provide emotional and informational support to smokers, furnishing them with encouragement and the opportunity to draw insights from successes and failures. Additionally, the competition mechanism may motivate smokers to keep abstinent to surpass other smokers’ efforts.

## 7.9 Theme 6: Disengagement with social features

Although most interviewees liked the social features within apps, some reported that they seldom use social forums. Those smokers who strongly believed that smoking cessation is a personal and private issue were likely to engage less with the social features. An interviewee, who had previously sought help from colleagues in the office but ultimately failed, was convinced that quitting smoking is something that can

only be accomplished by oneself and dismissed the effects of social support in smoking cessation. Therefore, she was unwilling to spend time on the social features of the app. This indicated that only smokers who believed they could benefit from social support would engage with social features.

*“Social functions are of no use to me... Last year, I decided to quit smoking, and then I asked my colleagues to monitor me... After some days, I smoked enough at home in the morning before going out, and as soon as my colleagues left the office in the evening, I would rush out to smoke. It is impossible to rely on others to help quit smoking. Quitting has to be accomplished through your efforts.”* (Interviewee 8, Female, Smoking Cessation Army)

Smokers who prefer to face and address challenges alone rather than seek social support resisted the social components within apps. For these smokers, seeking social support in a smoking cessation app may seem like a waste of time and irrelevant to quitting smoking. Therefore, they tend to ignore the social features. For example, an interviewee did not communicate with other users within the social forum because he thought it was time-consuming.

*“I haven’t explored the social forum because I feel like I don’t need it... I prefer not to use social functions extensively as they can be quite time-consuming for me. It had been troublesome enough to deal with social interactions in real life.”* (Interviewee 7, Male, Smoking Cessation Army)

Interview data also showed that another issue that will lead to disengagement with social features is the poor management and regulation of these platforms. Better regulation of these social features is needed to maintain a positive and safe social space within apps, enabling users to gain more social support from the social components.

*“My experience using this app could be better if it had improved social forum management. For example, functions like blacklisting someone who bullies others could decrease the influence of negative comments.”* (Interviewee 5, Female, Smoking Cessation Army)

An interviewee expected the app to have better language governance to promote smoking-related topics and positive comments and avoid negative comments that will demotivate users to stop smoking. To achieve the intended social support function, language must be managed to build a supportive and encouraging environment where smokers can seek social support from it. Additionally, poor language management on social features can have counterproductive effects on smoking cessation because users engaging with the social features might be affected by negative or aggressive comments, which can undermine their motivation and confidence to quit smoking.

*“Some chat contents in the social forums within the app were not very positive. I think the atmosphere of the chat room needs to be managed. Quitting smoking is a positive thing, and if there is a lot of negative or irrelevant content in the social forum, it will definitely affect quitting smoking.”* (Interviewee 23, Male, Smoking Cessation Army)

If negative comments were allowed to spread within the groups, such as bullying or mocking others, it would create an unsupportive atmosphere, which might demotivate users to use the social function. Negative comments within apps could potentially undermine smokers' motivation towards smoking cessation or induce anxiety and stress, making it even more difficult to stick to abstinence goals. Furthermore, negative comments can be contagious, leading to negative moods and attitudes among users across the social forum. When new users join, they may be dissuaded by this negative atmosphere or reluctant to share their experiences. An interviewee said he disengaged from the social function within the app because of the negative comments.

*“There is also chat content in the social forum that is irrelevant to quitting smoking, or some people would say they have relapsed. I remembered there was a smoker who started to check in one day, marking it as day one, and then posted the same content again on the next day and marked today as day one again. You can know from their comments that they did not quit smoking at all...I chose to ignore all the*

*negative information like this, and I did not want to share my experience in the forum.”* (Interviewee 19, Male, Smoking Cessation Expert)

In summary, the social features of an app are essential because smokers often experience social isolation and potentially lack social support in real life. When smokers seek social support, and the app provides a supportive and active social platform, they can benefit from it. Conversely, due to the complexity of smokers' backgrounds and personality traits, different smokers may have varying views on the role of social support in quitting smoking. Those who do not seek social interactions or do not believe in the effects of social support may not use the app's social features. Even if smokers are willing to use the social features, if the app's social platform is not well-managed, leading to negative feedback, they might feel that these features negatively impact their smoking cessation motivation, thus reducing their engagement with social features.

#### 7.10 Theme 7: Education on managing withdrawal symptoms

The stimulation of nicotine receptors releases a range of neurotransmitters, including dopamine, which makes smokers feel pleased after smoking (Benowitz, 2010). However, the nicotine receptors in the brains do not decrease at once when smokers stop smoking. Therefore, smokers need to intake nicotine to maintain the same level of contentment as before. Withdrawal symptoms often occur among smokers because they have become accustomed to nicotine and become dependent on it. These withdrawal symptoms usually occur soon after the last cigarette, peak during the first few days of quitting, and gradually decrease over a month (NCI, 2022). The type, intensity, and duration of withdrawal symptoms vary from person to person. Therefore, mastering effective strategies to manage withdrawal symptoms is key to preventing relapse (Robinson et al., 2019, NCI, 2022).

Uncertainty regarding what withdrawal symptoms will happen and why they happen can cause anxiety during smoking cessation (Carleton, 2012). Interview data showed that apps provide smokers with educational information about withdrawal symptoms, such as what the symptoms are, the reasons why these symptoms occur, and how long they will last and can reduce anxiety. If smokers do not understand why they

are experiencing withdrawal symptoms, they may feel more anxious about the uncertainty. This indicates that although withdrawal symptoms are common among smokers, understanding why these symptoms occur, how they can be alleviated, and how long they will last is very important for reducing anxiety in smokers.

*“I checked the withdrawal symptoms in the app and found that my oral ulcers were likely caused by quitting smoking. The app explained that the occurrence of oral ulcers is due to the change in chemical substances in my body, as nicotine in the blood decreases, so I did not worry too much about it. It was possible that the body might have certain reactions.”* (Interviewee 23, Male, Smoking Cessation Army)

In this study, among various withdrawal symptoms, interviewees experienced, having cravings is the most prevalent and influential. Cravings can be physiological and psychological in nature (Meule, 2020). Physiological cravings can happen due to smokers’ physiological dependence on nicotine, while psychological cravings can arise because smoking has become an acquired habit integrated into smokers’ daily lives. For instance, smokers may regard smoking as a way to relax, or they are accustomed to smoke in specific situations like after meals or as soon as they wake up. Although physiological cravings may diminish over time, changing an acquired habit requires a longer duration (Hughes, 2010).

*“My withdrawal symptom is experiencing cravings...I was irritable and restless because I cannot smoke when cravings come.”* (Interviewee 4, Male, 3 Krystal Smoking Cessation)

*“The withdrawal symptoms include still having nicotine cravings after a long time, which can be even more intense than before (quitting smoking). Cravings can sometimes make it hard to concentrate at work, and it also influences my sleep quality.”* (Interviewee 10, Male, Quit Smoking Tool)

Interview data showed that apps educate smokers about tips to manage cravings. Among the methods mentioned in apps for managing cravings, one of them involves employing different strategies to distract users from smoking. For example, apps

direct smokers to do some alternative behaviours to replace smoking, such as doing exercise, holding breath, having a healthier diet, and drinking water.

*“The app also provides some small tips for controlling smoking cravings, such as holding your breath, distracting attention, or eating something, etc.”* (Interviewee 2, Male, Smoking Cessation Army)

It was interesting that most interviewees did not engage with this feature frequently. The reason might be the low intensity of the provided support. Interviewees highlighted that apps provided general information that lacked personalisation and further instruction. When the tips are general and not personalised, smokers may find this feature not helpful, and therefore, they may not spend time engaging with it. In addition, even if apps provided tips, such as exercises and meditation, to manage cravings to prevent relapse, they only provided textual information on the strategies to manage cravings. Still, they lacked further guidance to push smokers to implement these strategies in practice, such as the use of exercise videos within apps. App developers could consider providing multi-faceted resources within apps that align with the provided advice, such as providing a set of videos on exercise that can be chosen by smokers, which can increase the likelihood of smokers following the app’s advice.

*“I just read the tips to control cravings in the early stages of smoking cessation, but I did not find them particularly useful because they mostly consisted of information I already knew. They were common knowledge to me.”* (Interviewee 7, Male, Smoking Cessation Army)

*“When I accessed the craving management tips, there were some methods presented, such as running or meditation. However, the app only offered these in text form and did not provide further support.”* (Interviewee 10, Male, Quit Smoking Tool)

Brief and non-personalised advice may not be sufficient to engage users who have already implemented certain craving management strategies. One interviewee, who already had a habit of running to shift her attention from cravings, mentioned that

although the app suggests exercising to distract attention, such general advice might not offer any additional help or new information.

*“This app advised me to shift my focus by exercising, but it did not provide any further guidance...Even before I used this app, if I had the craving for smoking, I might go downstairs and run for a while to get rid of the craving.”* (Interviewee 12, Female, Smoking Cessation Army)

Another reason for this feature’s low engagement level might be that smokers believe cravings are short-lived. Therefore, they found these tips unnecessary. This also reflected their perception that quitting smoking relies primarily on their determination, which reduced their expectations for managing cravings. It indicated that for smokers who did not expect to benefit from this feature, the engagement level could be low.

*“During particularly irritable moments, there might be cravings to take a puff, but it only lasted for a few seconds...Cravings passed very quickly.”* (Interviewee 7, Male, Smoking Cessation Army)

To distract smokers from cravings, aside from educating on tips, apps also provided features that aimed to shift smokers’ attention to positive aspects. Take *Smoking Cessation Army* for example, it provided motivational stories to distract smokers from cravings. These short stories typically convey positive thoughts, such as the power of persistence.

*“There are some motivational stories within the app to distract you from cravings. These stories often convey the idea that persistence will yield positive results.”* (Interviewee 5, Female, Smoking Cessation Army)

However, not many interviewees engaged with this motivational story feature to distract themselves. One interviewee explicitly expressed that this feature was not helpful. It indicated again that for smokers who do not believe they can benefit from this feature, the engagement level could be quite low.

*“I only read the motivational stories once, and I thought they were not useful. They were not relevant to smoking cessation at all. I don’t think it will help me control my cravings.”* (Interviewee 8, Female, Smoking Cessation Army)

Overall, smoking cessation apps incorporate some features to help smokers understand withdrawal symptoms and how to manage them, such as providing tips to distract them from cravings to prevent relapse. However, this study found that the engagement level with these features was low. The first reason was for smokers who do not believe these features will benefit them, user engagement on these features could be deterred. In addition, the low intensity of these features may demotivate smokers to continue using these features as they may find these features cannot provide further and tailored support.

#### 7.11 Theme 8: Withdrawal symptoms recording

Another app feature related to withdrawal symptoms, which was mentioned frequently by smokers, was the recording function. It enables smokers to record their experience of withdrawal symptoms as well as craving details. Smoking becomes a habit when it is repeatedly associated with specific situations, emotions, or times of the day (Marlatt and Gordon, 1985). For example, a smoker might habitually light up a cigarette after meals, during breaks at work, or in social situations.

*“I was used to smoking a cigarette in the morning and smoking another one before going to bed.”* (Interviewee 1, Male, Smoking Cessation Army)

*“In some specific situations...for example, after meals, or in the bathroom, I wanted to smoke.”* (Interviewee 5, Female, Smoking Cessation Army)

*“I had a habit of smoking, and it became an automatic action. Sometimes I did not realise that I wanted to smoke, but my hand would just move to light a cigarette.”*  
(Interviewee 11, Male, Smoking Cessation Army)

These high-risk situations reinforce smoking behaviour, making it an automatic response to those cues. For smokers who have integrated smoking into their daily

lives, losing the company of cigarettes can be extremely painful. Cravings are unavoidable, and it is difficult to refuse a cigarette in a habitual situation.

*“When I started to quit smoking, I suddenly realised that something was missing in my life. Can you imagine how difficult it was...This made it easy to relapse again.”* (Interviewee 1, Male, Smoking Cessation Army)

Therefore, identifying these 'high-risk' situations that trigger smoking behaviour is a vital step towards long-term quitting, allowing smokers to consciously avoid these high-risk cues (Marlatt and Gordon, 1985). Previous research found that the recording feature enables smokers to journalise craving details, such as time, location, intensity, and reasons (Bendotti et al., 2022, Zhang et al., 2023). This feature is designed for smokers to become more aware of their craving patterns, therefore identifying high-risk situations and planning coping strategies (Schick et al., 2018, Bendotti et al., 2022). Interview data also showed that the craving recording feature can serve as a self-reflection tool, allowing smokers to gain a deeper understanding of their smoking patterns so they can take more effective measures to prevent relapse rather than passively waiting for cravings to occur (Naughton, 2017, Klein et al., 2019, Bendotti et al., 2022).

*“The app has the function enables users to record cravings, including the intensity and how the feeling was when cravings come.”* (Interviewee 24, Male, No Tobacco)

*“The app has a feature for recording cravings. When I had a craving for a cigarette, I recorded it in the app. I continued to monitor my cravings regularly to identify the situations or times in which they were most likely to occur.”* (Interviewee 2, Male, Smoking Cessation Army)

However, interview data also showed that this feature did not work effectively for all smokers. It should be noted that smokers' existing attitudes towards cravings affect their expectations of the craving recording feature. Smokers who recognise that it is normal to have cravings were more likely to expect to benefit from recording them. Quitting smoking is a gradual process that may involve multiple attempts, which requires smokers to have a more realistic attitude towards the existence of cravings

(Marlatt and Gordon, 1985). This indicated an important contextual factor for the success of the recording feature was the open attitude towards cravings. How smokers define success and failure in smoking cessation significantly impacts the way they approach smoking cessation and the acceptance level of specific features, such as recording cravings.

Many smokers define successful smoking cessation as complete abstinence from smoking, viewing any relapse as a total failure (Zhu et al., 2022). This 'all-or-nothing' mindset can intensify the fear of cravings, potentially leading to anxiety and a heightened risk of relapse. Meanwhile, the criteria of total abstinence may have a counterproductive effect on those attempting to quit smoking because once they experience a relapse, they might feel defeated and guilty, believing that they have failed in smoking cessation and that there is no need to continue their efforts to quit (Marlatt and Gordon, 1985, Sharma and Anand, 2019). The 'total abstinence' criteria can lead smokers to overlook features like craving recording because they do not realise that a reduction in the intensity of cravings, a decrease in their frequency, or an enhanced ability to resist cravings are all signs of progress in the process of quitting smoking (Abdullah et al., 2005).

For example, one interviewee's avoidance of recording cravings in the app highlighted a common reluctance among smokers who held the belief that successful smoking cessation meant not having smoking cravings. The 'all-or-nothing' mindset can demotivate smokers to expect to benefit from recording cravings, therefore leading to disengagement with this feature.

*"I did not use the app to track my smoking cravings because I wanted to quit smoking completely, so I did not want to engage with information related to cravings."* (Interviewee 12, Female, Smoking Cessation Army)

Among interviewees who regularly used the craving recording feature, it was found that attitudes towards cravings were more open. An interviewee 'rewarded' himself with a cigarette on weekends, and he thought this approach could better help him to manage and control cravings. The interviewee recorded each craving and relapse in the app while he persisted with this smoking cessation plan.

*“I also want to quit completely, but I cannot do it. One week of abstinence is my limit. I reward myself with one or two cigarettes every weekend. I also recorded my cravings and relapses within the app.”* (Interviewee 19, Male, Smoking Cessation Expert)

Another interviewee also held an open attitude towards having cravings. He believed that both ‘total abstinence’ and being able to control cravings can be seen as successful smoking cessation. This interviewee was one of the few smokers who frequently used an app to record their cravings during the first year of using the app.

*“I know another smoker who was very skilled at managing his smoking cravings. I think he is a successful quitter as well because he can control his nicotine cravings efficiently.”* (Interviewee 1, Male, Smoking Cessation Army)

*“I used it (craving recording function) very often during the first year, sometimes I recorded seven or eight times in one day.”* (Interviewee 1, Male, Smoking Cessation Army)

In addition, this interviewee also recognised that observing a reduction in cravings served as tangible positive feedback, which significantly boosted optimism and confidence in the ability to stop smoking. This insight underscores the importance of observable progress in the smoking cessation journey, aside from total abstinence. As cravings diminished, the interviewee found an increased sense of control over smoking cessation, pushing him to maintain the efforts and stay abstinent.

*“If you are quitting smoking, you definitely have cravings sometimes, but you can see that your cravings are becoming less and less, it is a positive psychological hint for yourself. It made me believe that I can succeed in smoking cessation.”* (Interviewee 1, Male, Smoking Cessation Army)

Another effective mechanism mentioned by smokers was releasing negative emotions through recording withdrawal symptoms. It is important to find an appropriate way to vent negative emotions rather than suppressing them during

smoking cessation (McKee et al., 2011, Chervonsky and Hunt, 2017). One interviewee had the habit of recording the smoking experience using the memo function on his phone before using the smoking cessation app. Therefore, he kept this habit of journaling his feelings so he could see how his withdrawal symptoms have changed, and this can be a way to release negative emotions caused by smoking cessation.

*“I used the memo function on my phone to briefly record how I felt when I started smoking cessation...Keeping a record of my feelings can also serve as a form of venting the negative emotions when withdrawal symptoms happen.”* (Interviewee 7, Male, Smoking Cessation Army)

However, interviewees who did not have the pre-existing habit of recording withdrawal symptoms did not use the app to journal these symptoms. When they started using the smoking cessation app, they did not expect recording cravings within apps to benefit them. For example, an interviewee mentioned that he just ignored the app feature of recording cravings, preferring to spend time on what they consider more valuable activities. This indicates that smokers who do not believe that this type of recording is practically helpful in quitting smoking will not actively engage with this feature.

*“I didn’t actively record my cravings within the app, nor did I spend too much time analysing cravings because I believe my time should be better spent elsewhere.”* (Interviewee 7, Male, Smoking Cessation Army)

Overall, the withdrawal symptoms recording feature serves as a way to clarify smoking patterns, although interviewees in this study did not show a high engagement level with this feature. For smokers who do not hold an open attitude towards cravings, the recording feature was not thought to be helpful, therefore decreasing their expectations and engagement with this feature. In addition, this study also found that whether to engage with this feature also depends on the extent to which smokers expect to benefit from it. This feature was found to be effective for smokers who are realistic towards having cravings during smoking cessation and hold the view that they can benefit from recording their withdrawal symptoms.

Three effective mechanisms were identified from the interview data. Firstly, journaling withdrawal symptoms could be regarded as a way to vent negative emotions, decreasing the likelihood of relapsing. Secondly, regularly recording cravings could help smokers become more aware of their craving patterns, allowing them to identify high-risk situations and be prepared for them. Lastly, seeing cravings diminish serves as a way to boost confidence in smoking cessation.

## 7.12 Theme 9: Usability

Usability is composed of learnability, memorability, effectiveness, efficiency, and satisfaction (ISO, 2018). The scope of each component is elaborated in Chapter 2. A product with good usability enables users to achieve their goals effectively, efficiently, and with satisfaction (ISO, 2018). In this study, three attributes were found to be relevant to the usability of smoking cessation apps: ease of use, multiple modalities, and visual design.

### 7.12.1 Subtheme 9.1 Ease of use

Ease of use reflects important aspects of usability, especially learnability and user satisfaction (ISO, 2019) (Chapter 2, section 2.6.3). Ease of use is a prerequisite for the success of smoking cessation apps because it affects user engagement. Smoking cessation apps that are easy to use can quickly attract new users and encourage them to engage with the app.

*“The app is easy to use, and I can quickly understand the function of each button. For example, the check-in button. I think this is also why I chose to continue using this smoking cessation app. I had used another app before, which was not very intuitive. I remember using the check-in function, but it turned out that the button was for recording relapses.”* (Interviewee 5, Female, Smoking Cessation Army)

*“Using this app is very convenient, and the abstinence days recording feature is also very easy to use. Just one click, and you can record another smoke-free day... I find it not complicated, very simple and clear.”* (Interviewee 13, Male, Smoking Cessation Army)

An interviewee mentioned a limitation of apps compared with computers, that apps are not easy to use when reading long posts due to the small screen. This indicates that a key aspect of ease of use is that the app considers the limitations of the mobile phone screen.

*“For example, if you want to read a long post, you probably will not read it on phone screens, like I mentioned before, you are prone to use a PC to read it, or on iPad, or Mac. I will not read it (long posts) on mobile phones, too inconvenient, too laborious.”*

(Interviewee 1, Male, Smoking Cessation Army)

Overall, ease of use is essential to the success of smoking cessation apps. It influences how easily users feel they can find the features that meet their needs to achieve goals and how much effort is needed to interact with these features. In other words, ease of use is one of the factors that determines whether users can achieve their smoking cessation goals.

#### 7.12.2 Subtheme 9.2 Multiple modalities

Providing multiple modalities, such as texts, audio, and video formats, in smoking cessation apps can enhance their effectiveness and efficiency (Chan et al., 2017). Combining different media formats provides more comprehensive support to users (Oh et al., 2018). In this study, smoking cessation apps that employ multiple modalities were found to be more helpful in assisting users in stopping smoking. Smokers expressed that they expected apps to employ multiple modalities.

*“The more formats, well, the more diverse the formats are, the more I can learn and gain. The more, the better.”* (Interviewee 4, Male, 3 Krystal Smoking Cessation)

Smoking cessation apps should consider using multiple media formats to accommodate changing user needs depending on the context in which they are used.

*“I think if an app can provide different formats, I would be more willing to use it. For example, before going to bed, I like to read text in a quiet environment, but if I feel*

*like my eyes are tired after a long day of work, I might prefer listening to audio. If the app only has text, I might find it very boring and less appealing.”* (Interviewee 8, Female, Smoking Cessation Army)

The multimedia approach meets different user needs and preferences since each media format has its advantages that cater to different usage situations (Kim and Gilman, 2008). For example, video format is highly favoured by users seeking a more dynamic and engaging way of learning, as videos combine visual content, audio elements, and even interactive elements. An interviewee mentioned that the combination of subtitles, video, and audio can also make content easier to understand.

*“Heavy texts can make user tired of reading them. I think video format is better because we can see the subtitles on the screen and hear the sounds.”* (Interviewee 13, Male, Smoking Cessation Army)

*“I believe that videos would be very effective because they provide a visual presentation, which can often be more impactful than text-heavy written articles.”* (Interviewee 10, Male, Quit Smoking Tool)

Another interviewee stated that images that showed the horrible effects of smoking can provide a more significant visual impact than textual description, which can offer stronger motivation to quit smoking.

*“There are some images in the app, such as the picture showing smokers' lungs, which provided a stronger stimulus to me than textual descriptions and motivated me to quit smoking.”* (Interviewee 15, Male, Smoking Cessation Army)

Additionally, the audio format allows users to continue receiving the information and support provided by the app while doing other tasks, thereby enhancing user engagement. For example, the audio format of delivering smoking cessation information allows users to interact with the app's features without looking at the screen, such as before going to sleep.

*“When I was stopping smoking, I always listened to the audiobook about smoking cessation when I lay in bed before falling asleep.”* (Interviewee 6, Male, Smoking Cessation Army)

*“The audio format...I can listen to the light music within the app when I have cravings. I can also use the app to play music to distract myself from cravings when I am doing something else.”* (Interviewee 21, Female, Quit Smoking)

Overall, smoking cessation apps that incorporate multiple modalities can better meet diverse user needs and preferences. They allow users to choose the format that best suits them, thus increasing user engagement and helping smokers effectively achieve their goals.

### 7.12.3 Subtheme 9.3 Visual design

Visual design elements, such as colour scheme and aesthetics, play a crucial role in increasing user engagement (O’Brien et al., 2018). A smoking cessation app with a visually appealing design will attract users and make users more willing to use the app.

*“The app's colour is quite pleasant. The green colour is soothing for me.”*  
(Interviewee 9, Male, Smoking Cessation Army)

However, users have different preferences regarding the colour scheme. The aforementioned interviewee liked the green colour because it was soothing and pleasant to him, while another interviewee who used the same app felt the green interface did not look youthful and did not appeal to the younger age group.

*“At the beginning, I didn't particularly like the name and appearance of the app...the green colour of the app's icon and interface did not look very youthful.”* (Interviewee 5, Female, Smoking Cessation Army)

The contrasting findings illustrated the diversity in preferences on interface design among app users, highlighting the need for app designers to create a customised

interface, allowing users to select their preferred colour schemes and interface styles. In addition, users may associate different colours and design elements with different meanings, which emphasises the importance of giving users autonomy to choose their preferred interface design elements (Wang and Li, 2017).

*“I hope the interface style is serious like it's monitoring me. I think it can be more serious, which would make me feel disciplined. As for colours, I don't have any specific preferences, but black might be suitable as it conveys a more serious tone. Additionally, some interface elements and icons can also be designed to appear more serious, urging us to be stricter with ourselves.”* (Interviewee 10, Male, Quit Smoking Tool)

Overall, visual design, such as aesthetics, affects user engagement in smoking cessation apps because customisable visual design can increase user satisfaction. The diversity in users' preferences on visual design underscores the importance of customisable interfaces, allowing users to choose their preferred colour schemes and design styles.

### 7.13 Theme 10: User Experience

User experience is users' responses or perceptions from using or anticipating a product or system (ISO, 2010). It has a prominent influence on the effectiveness of smoking cessation apps in helping people quit smoking (Sutcliffe, 2016). A positive user experience can increase user engagement, thereby enhancing the likelihood of continuous app use.

#### 7.13.1 Subtheme 10.1 User privacy

Users' willingness to download and engage with an app is influenced by their trust in the extent to which an app protects their personal information (Borghouts et al., 2021). When users feel their personal data is securely processed and their privacy is respected, they are more likely to have a positive user experience and want to keep using the app.

However, when asked whether they were worried about privacy issues, all interviewees indicated that they did not worry about privacy issues and believed their privacy was protected. This indicated a potentially widespread underestimation of the importance of privacy in app usage. Users often place implicit trust in major app stores, believing that apps downloaded there are entirely secure. An interviewee mentioned that he trusted the app because it was downloaded from Huawei's app store.

*"This app was downloaded from Huawei's app store. It does not require any personal information like my name. I feel that if there were privacy concerns, it would more likely occur with unauthorised or unofficial apps that secretly collect data. This app should provide some level of security because it is available on Huawei's official app store."* (Interviewee 20, Male, No Tobacco)

Another reason might be that users employ strategies to protect their privacy based on their understanding of what data can be collected and how data is collected by the app (Al-Sharo, 2019). However, users may not fully understand to what extent apps can collect and use their data or underestimate the risk of data misuse by apps.

Interviewees believed their data would not be at stake if they did not use sensitive data, such as real name, photo number, etc.

*"My profile picture is the photo of my cat. No privacy issues at all."* (Interviewee 8, Female, Smoking Cessation Army)

*"I used the pseudonyms and a virtual profile picture within the app. I didn't use my real name or pictures of myself. I am not worried about any privacy issues."*

(Interviewee 4, Male, 3 Krystal Smoking Cessation)

*"I haven't used the features that require logging in with a phone number. I'm just a guest... I don't think it's necessary to log in. I only need to use the features that guests can use, like checking in, viewing my health recovery progress, etc."*

(Interviewee 5, Female, Smoking Cessation Army)

Overall, this study found that users feel their privacy is well protected, although they may have underestimated other factors that could compromise it. This default sense of security builds users' trust in the app, ensuring that users do not reduce their engagement due to concerns about data security.

### 7.13.2 Subtheme 10.2 Record keeping

In smoking cessation apps, providing the record-keeping feature is important to improve user experience since users may have several attempts during smoking cessation. The record-keeping feature provides convenience for users who uninstall the app and download it again, and users can pick up their achievements without losing data and progress. It increases long-term user engagement because users are more likely to continue using the app if they know their data and progress are saved with continuity.

*“I downloaded this app again, and it kept my records in it. I have an account in it so that the app will record my progress and data all the time.”* (Interviewee 22, Male, Smoking Cessation Army)

Interview data showed that the record-keeping feature required users to create an account within the app, meaning smokers needed to register. Allowing apps to store previous data on their servers can raise data security concerns. However, due to the trust in these apps (Subtheme 10.1), no interviewee reported worrying about their data security while enjoying the record-keeping feature.

*“I have changed my mobile phone several times but reinstalled this app each time. As long as my account is still within the app, it won't interrupt the recording. It has been six years since I started to use this app.”* (Interviewee 1, Male, Smoking Cessation Army)

Overall, the record-keeping feature improves user experience and strengthens the long-term connection between users and apps, which is crucial for apps that aim for sustained efforts for behavioural change, such as smoking cessation.

### 7.13.3 Subtheme 10.3 Advertising and membership fees

In this study, advertisements and membership fees are two factors that influence user experience. Some interviewees mentioned that they encountered a few seconds of advertisements when entering the app. These advertisements could slow down app loading, increasing user waiting time.

*“I think the advertisements have some impact on my experience. I can directly enter the app interface if there is no advertisement, but now, I have to wait for several seconds then click ‘skip’.”* (Interviewee 13, Male, Smoking Cessation Army)

However, most smokers showed a high tolerance towards advertisements in this study. This could be related to the brief duration of the advertisements that it was just a few seconds and users can choose to ‘skip’ advertisements easily. An alternative explanation might be that these users have become accustomed to seeing advertisements on various apps since many apps contain advertisements nowadays. For free-to-use apps like a smoking cessation app in the Chinese market, users may even be more tolerant of the presence of advertisements as they understand that this is the financial source that supports the app’s maintenance and operation.

*“The app I use now has some advertisements. I see some advertisements when I enter the app, but I can simply skip them. I think being able to use the app for free is quite good. Apps also need financial sources to be maintained, and they might rely on advertising revenue to keep running. I don’t see any major issues with that.”*  
(Interviewee 4, Male, 3 Krystal Smoking Cessation)

Some interviewees mentioned the need to pay a membership fee to unlock some premium features, which may negatively affect user experience for those who are accustomed to free content or are uncertain about the app's value. The decision to pay membership fees largely depends on users’ perception of the value provided by the app (Wei et al., 2020). If they believe the value offered by the app deserves the expense, they might be more willing to pay the fee to access advanced features. Therefore, interviewees who believed that the success of smoking cessation mostly

depends on personal persistence were dissatisfied with the membership fees for accessing premium features, which often have no advertisements. Some even mentioned that they would not spend time on these advanced features even if they were free to access them.

*“It (the app) used to be pretty good before, but now they have added premium features, which means you have to pay to access certain functions. That’s not so great because many features are restricted for non-paying users.”* (Interviewee 2, Male, Smoking Cessation Army)

*“There’s a premium section, which is only accessible to members. Even if they offer it to me for free, I wouldn’t bother to click and check it.”* (Interviewee 7, Male, Smoking Cessation Army)

*“I think the membership fee is one of the things I am not satisfied with. If an app charges me a costly membership fee to use it, I think I won’t use it anymore.”* (Interviewee 16, Female, Smoking Cessation Army)

Overall, whether advertisements and membership fees negatively affect user experience depends on users’ perception of their value. On the one hand, they view advertisements as a necessary trade-off for using the app for free, so they can see the value of watching the advertisements for a few seconds. On the other hand, smoking cessation is viewed as a goal that is predominantly achieved through one’s persistence, and smokers cannot see the value of becoming a premium member of the app. Thus, interviewees were reluctant to pay for the membership fee.

#### 7.13.4 Subtheme 10.4 Gamification

Gamification is the application of game elements in non-game contexts, such as smoking cessation apps, aiming to increase user engagement and boost user experience (Bitrián et al., 2021). Previous research has identified different gamification features that apps provide to improve user experience, such as the achievement and progression elements (Bitrián et al., 2021, El-Hilly et al., 2016). In

this study, the gamification elements mentioned by interviewees included the rank and reward systems.

Take the *Smoking Cessation Army* as an example, it employs a rank system which allows users to unlock new military ranks (Appendix 13) when they have checked in for certain days. The advancement in the military rank symbolises the achievements of smoking cessation. Furthermore, the ranking system makes the user experience more enjoyable, increasing user satisfaction and making users more willing to engage with the app.

*“It can be used to check-in smoke-free days. Viewing these numbers puts you in a better mood... From the soldier to the commander, there's still a sense of achievement.”* (Interviewee 9, Male, Smoking Cessation Army)

*“Your rank gradually increases in a military rank system as you keep checking in. I find this aspect quite interesting.”* (Interviewee 6, Male, Smoking Cessation Army)

In *Smoking Cessation Army*, another gamified element of the app is providing rewards to users who achieve specific days of continuous smoking cessation, such as 21 or 100 days. The rewards, such as a real necklace engraved with the number of smoke-free days, as a return for their efforts in quitting smoking and as proof of achievement, greatly encourage smoking cessation efforts, helping them to persist in quitting. Even if these rewards require them to pay in the app's store, users are willing to pay for them because they perceive these rewards as valuable. However, not all smokers were willing to pay for these rewards. Similar to the finding regarding paying for membership fees, only interviewees who recognised the value of these souvenirs will spend money on them.

*“You can apply for a physical medal, but you need to pay for it. However, if you successfully quit, receiving that medal can be a significant psychological reward at the time.”* (Interviewee 1, Male, Smoking Cessation Army)

*“Because it (buying these physical medals or rewards) is a way to motivate me, spending this money is actually quite valuable.”* (Interviewee 1, Male, Smoking Cessation Army)

Overall, gamification features boost user experience by making the use of smoking cessation apps more enjoyable and making the achievements visible. Smokers who see the value of real rewards are willing to spend money on them since they can celebrate their achievements.

#### 7.13.5 Subtheme 10.5 Personalisation

Personalisation means apps provide tailored support based on user needs and preferences. Providing generic and standardised support may not meet the specific needs of some users. Personalised support that considers users' preferences and needs can provide customised services or content based on users' unique needs and preferences.

Interview data showed that personalised features allow apps to meet different user needs and preferences. For example, as mentioned in subtheme 9.3, 'visual design', users have different preferences for app design style and colour scheme. If apps offer personalised style settings, users can freely choose their preferred style, thus improving their user experience.

However, when asked whether the apps provided personalised features, smokers felt the apps lacked personalisation, which negatively affected their user experience.

*“I quite look forward to these personalised features you mentioned (personalised reminders or personalised educational contents), but I feel the Smoking Cessation Army does not have such features, and it lacks these rich, personalised features.”* (Interviewee 13, Male, Smoking Cessation Army)

*“It's boring to use this app sometimes because it doesn't have highly personalised features.”* (Interviewee 4, Male, 3 Krystal Smoking Cessation)

Interview data also showed that smokers would engage less with generic features for which they would like to see personalisation on features that they perceive as lacking personalisation. For example, one interviewee reported that when accessing the withdrawal symptoms education feature, he found the provided information was generic. Therefore, his need was not satisfied, and he preferred to search for information online rather than within apps.

*“The app feature that provides methods to manage cravings didn't have a significant impact; for example, some of the content focuses on quitting smoking methods and symptoms...you can find similar information elsewhere...so why do I have to use this app? Searching for information online is more convenient.”* (Interviewee 1, Male, Smoking Cessation Army)

Although personalisation features are expected to meet different user preferences and needs, interviewees felt that apps generally lacked personalised features. For smokers who feel the apps are unable to provide personalised support, user engagement levels will decrease because they could use alternative resources instead of apps.

## CHAPTER EIGHT: Refinement of programme theories

### 8.1 Introduction

This chapter describes how the initial programme theories were refined based on the qualitative data analysis findings in Chapter 7. The refined programme theories were presented using 11 CMOCs. Programme theory 1 (boosting motivation and self-efficacy) has four CMOCs, programme theory 2 (social support) has three CMOCs, programme 3 (relapse prevention) and 4 (sustained user engagement) have two CMOCs each. These CMOCs were used to explain how smoking cessation apps help Chinese smokers stop smoking. Specifically, they address the aim of the study regarding examining what aspects of smoking cessation apps work for Chinese smokers, under what circumstances, and why. Mind maps were used to present CMOCs.

### 8.2 Refined programme theory 1: Boosting motivation and self-efficacy

When motivated smokers engage with app features that show quitting progress (context), the benefits of smoking cessation, and the risks of smoking (resource mechanism), they become intrinsically or extrinsically motivated, and their self-efficacy in smoking cessation is strengthened (reasoning mechanism). This leads to both short-term and long-term abstinence (outcome). In contrast, when unmotivated smokers (context) encounter the same app features (resource mechanism), they may experience negative emotions (reasoning mechanism), which can trigger cravings (outcome).

When smokers believe smoking will lead to severe diseases and they are likely to develop these diseases (context), engaging with app features that provide new information about the risks of smoking (resource mechanism) helps them develop a deeper understanding of its harmful effects (reasoning mechanism). This increases their motivation to quit smoking (outcome). However, excessive negative information (resource mechanism) can evoke emotions such as anxiety and fear (reasoning mechanism), which may also trigger cravings (outcome). For benefit-oriented

smokers (context), app features highlighting the benefits of smoking cessation (resource mechanism) foster a sense of achievement (reasoning mechanism), further motivating them to quit smoking (outcome). Table 8.1 shows the CMOCs in programme theory 1.

<b>Contexts</b>	<b>Mechanisms</b>	<b>Outcomes</b>
<p>1. Smokers are motivated to stop smoking and believe apps can help them stop smoking and engage with app features that meet their needs</p>	<p>M1: Smokers' extrinsic motivation is boosted (reasoning) through engaging with app features that show quitting progress and benefits (resource) (e.g., health or financial benefits, achievement system)</p> <p>M2: Smokers' intrinsic motivation is boosted (reasoning) when they truly understand risks of smoking and benefits of smoking cessation through engaging with apps (resource) and when they get a sense of achievement and feel their smoking cessation journey are paying off through viewing quitting progress (resource)</p> <p>M3: Smokers' self-efficacy is strengthened (reasoning) as they see their quitting progress and achievements within apps (resource)</p>	<p>O1: Smokers stay abstinent in short term</p> <p>O2: Smokers stay abstinent in long term</p> <p>O3: Decreased user engagement, but stay abstinent in long term</p>
<p>2. Smokers are not motivated to stop smoking or do not believe apps can help them stop smoking</p>	<p>M1: User engagement, such as viewing abstinence days (resource), can be counterproductive by triggering negative emotions (reasoning), such as anxiety</p>	<p>O1: Cravings to smoking can be triggered</p>
<p>3. Smokers believe smoking will lead to severe diseases</p>	<p>M1: Smokers engage with app features that provide information on risks of smoking that</p>	<p>O1: Smokers are motivated to stop smoking</p>

<p>and they are likely to develop these diseases</p>	<p>they did not know before (resource) and they gain a deeper understanding of what harmful effects of smoking (reasoning)</p> <p>M2: Smokers engage with excessive negative stimuli (resource) and they link smoking cessation with negative emotions because they experience a sense of fear or anxiety (reasoning)</p>	<p>O2: Cravings to smoking can be triggered</p>
<p>4. Smokers are benefit-oriented</p>	<p>M1: Smokers engage with app features that provide positive stimuli (resource), such as benefits of smoking cessation, quitting progress etc., so they gain a sense of achievement and believe they are benefiting from smoking cessation (reasoning)</p>	<p>O1: Smokers are motivated to stop smoking</p>

Table 8.1: Summary of refined programme theory 1 (Boosting motivation and self-efficacy)

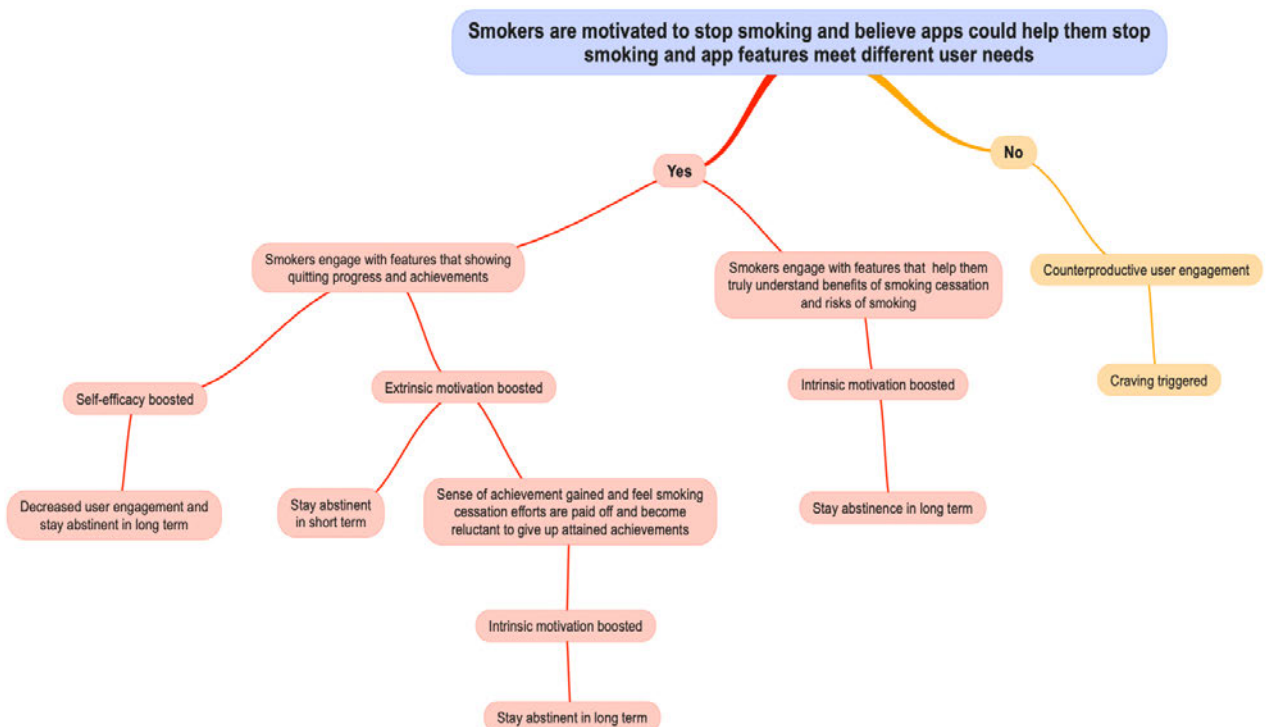


Figure 8.1: Mind map for programme theory 1, CMOC 1 and 2

Evidence from interviews emphasised that having sufficient motivation to stop smoking is the prerequisite for smokers to engage with smoking cessation apps effectively. Otherwise, they will not use apps or user engagement can be counterproductive. However, even though smokers are motivated to stop smoking, they will have very limited engagement with apps, or user engagement will be counterproductive if they do not hold the belief that a smoking cessation app can be an effective tool to assist smoking cessation. In other words, smokers having enough motivation to quit smoking, intrinsically or extrinsically, is necessary but not sufficient condition for smoking cessation apps to be effective. Smoking cessation apps can be effective only when smokers are motivated to stop smoking and also believe apps can be a useful tool to assist them to stop smoking.

Data from smokers' interviews also indicated that smokers' motivation to stop smoking is influenced by how smokers perceive the benefits and costs of smoking cessation alongside the merits and costs of smoking, and resources they have put into smoking cessation such as time. For example, smoking cessation can bring health benefits, but quitters have to endure withdrawal symptoms, while smoking harms health but can bring a sense of pleasure. This can be explained through the Protection Motivation Theory (Rogers, 1975). As introduced in Chapter 2, PMT indicated that individuals' motivation to take a protective behaviour, such as smoking cessation, is influenced by the threat appraisal and coping appraisal. To increase smokers' motivation to stop smoking, smoking cessation apps should emphasise the benefits of smoking cessation and the risks of smoking. Therefore, it outweighs the merits of smoking and the cost of smoking cessation (Figure 8.2).

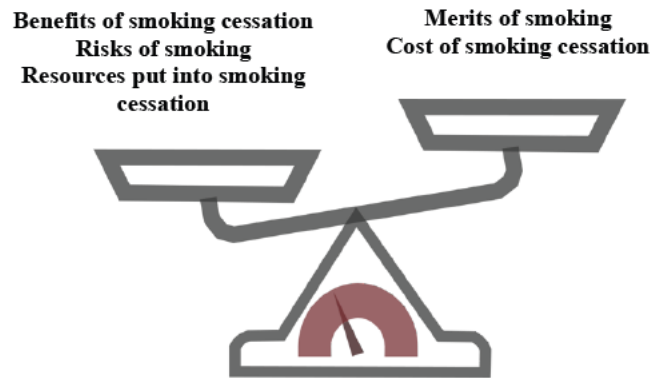


Figure 8.2: The way of being motivated to stop smoking

Throughout the long journey of smoking cessation, maintaining motivation plays a crucial role in persisting with smoking cessation in the long term. Displaying positive changes, such as health benefits, quitting progress, etc., are the strategies that smoking cessation apps employ to nurture smokers' extrinsic motivations. For example, when apps show how much money has been saved and how much progress they have made in smoking cessation, smokers' extrinsic motivation will be boosted. Apps also employ gamification features to offer extrinsic motivations to users, such as the achievement system using ranks, which could serve as additional incentives for them. However, these extrinsic motivations only exist for a short period. As smokers accumulate achievements in quitting, they gain a sense of achievement and feel that their efforts to quit smoking are rewarded and are reluctant to give up the attained achievements, thereby enhancing their intrinsic motivation and persistence with smoking cessation in the long term. This is the process of transforming extrinsic motivation into intrinsic motivation.

Smoking cessation apps also have features specifically designed to increase intrinsic motivation, such as using positive and negative stimuli to help smokers deeply understand the benefits of quitting smoking and its harms. Intrinsic motivation is the main driving force for maintaining long-term abstinence. Even when external incentives are absent, smokers are still motivated to quit smoking.

Except for the aforementioned positive stimuli, smoking cessation apps also provide negative stimuli, such as educating smokers on the risks of smoking. This is also specifically designed to increase smokers' intrinsic motivation. However, interview

data showed that negative stimuli do not hold a compelling effect as positive stimuli, as smokers already have a generic knowledge that smoking is harmful to health, yet they continue to smoke for various personal reasons. This indicated that only smokers who believe smoking can lead to severe diseases and are likely to get these diseases will engage with the app feature that educates the risks of smoking. Smokers who hold the self-exempting belief that negative consequences of smoking will not happen to them (Chapman et al., 1993, Guillaumier et al., 2016) will not engage with this feature.

Compared to negative stimuli, some smokers prefer to receive positive stimuli, such as health benefits, quitting progress, etc. When apps provide instant feedback on the benefits of smoking cessation, smokers can feel their efforts are paying off. In contrast, although negative stimuli, such as pictures to show the risks of smoking, can be a motivator for smokers who believe smoking is harmful, and they are likely to develop diseases due to smoking, this strategy should be used with caution because smokers with diverse backgrounds and knowledge level of risks of smoking may react differently to negative information. An unintended outcome that can happen to smokers who engage with the negative stimuli features is that too much negative information will threaten smokers. Therefore, it will produce counterproductive effects, such as evoking anxiety and fear. It is essential to strike a balance by providing positive and negative information. Alternatively, for smoking cessation apps to have the intended impact, apps could give users the autonomy to decide whether they prefer to receive positive or negative information based on their preferences.

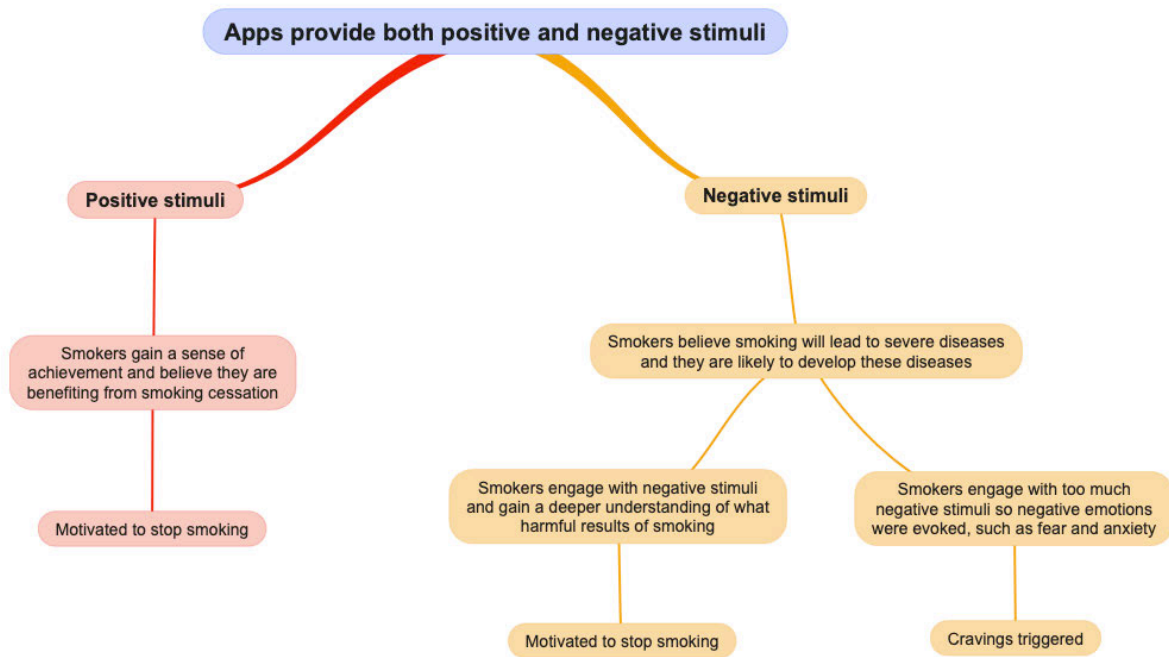


Figure 8.3: Mind map for programme theory 1, CMOC 3 and 4

Self-efficacy is the result of long-term persistence in smoking cessation. Interview data suggested that as smokers progress in their smoking cessation journey, their confidence in successfully quitting increases. Achievements along the way boost their self-efficacy. When smoking cessation apps display all positive changes, they enhance their belief in their ability to quit. As smokers start to see themselves as non-smokers rather than someone trying to quit, their engagement with apps tends to decrease. This highlights why the motivation provided by smoking cessation apps is particularly beneficial in the early phases of quitting (Prochaska, 2008). Over time, as users gain confidence in their ability to maintain a smoke-free life, they may use these apps less frequently.

Overall, this programme theory is about how smoking cessation apps could provide cognitive support to boost smokers' motivation to stop smoking. Although existing apps employ a range of strategies to strengthen users' motivation, these app features can be effective only when users are motivated to stop smoking and believe the effects of smoking cessation apps and app features can meet their needs. If these conditions are not met, user engagement will be limited or have counterproductive effects. When smokers decide to stop smoking and choose a

smoking cessation app to assist them in quitting, app developers should design a range of features that can meet different user needs to increase user engagement.

An unintended outcome of using smoking cessation apps is decreased user engagement as smokers gradually gain higher self-efficacy levels. This study found that smokers who were confident in their ability to stop smoking would decrease their engagement with apps. App developers should consider developing features targeting the needs of smokers at the initial stage. For smokers who are in the maintenance stage, where their self-efficacy level is high, user engagement level tends to decrease.

### 8.3 Refined programme theory 2: Social support

When smokers experience social isolation in real life and seek social support within apps (context), apps can provide a highly inclusive, non-judgmental, and supportive platform (resource mechanism). This fosters a sense of being supported regardless of their backgrounds (reasoning mechanism), encouraging smokers to engage with the social support features of the app (outcome). Conversely, for smokers who view smoking cessation as a personal issue or dislike socialising (context), the social features provided by the apps (resource mechanism) may not appeal to them (reasoning mechanism), leading to disengagement with these features (outcome).

For smokers who actively engage with social features (context), when they can connect with other quitters at similar stages of smoking cessation who share common goals and barriers (resource mechanism), it can create a sense of belonging and being understood (reasoning mechanism), motivating them to quit smoking (outcome). When advanced quitters share their experiences of achieving long-term abstinence within social forums and receive praise from peers (resource mechanism), they feel a sense of helping others (reasoning mechanism), which boosts their self-esteem (outcome). When smokers learn quitting strategies from successful quitters (resource mechanism), they believe they can apply these strategies to resist cravings and maintain abstinence (reasoning mechanism), increasing their confidence and skills in smoking cessation (outcome). When

smokers learn from the failed experiences of others to identify high-risk situations (resource mechanism), they become more vigilant against relapse (reasoning mechanisms), therefore, they are more likely to resist cravings (outcome). Additionally, when smokers share their quitting achievements within the app (resource mechanism), it fosters a positive sense of competition (reasoning mechanism), further motivating them to quit smoking (outcome). However, when social features are poorly managed or regulated (resource mechanisms), negative comments from others can demotivate smokers (reasoning mechanism), decreasing their engagement with these features (outcome). Table 8.2 presents the CMOCs in programme theory 2.

<b>Contexts</b>	<b>Mechanisms</b>	<b>Outcomes</b>
1. Smokers face social isolation in real life and seek social support within apps	M1: Apps provide a highly inclusive, non-judgmental and supportive platform that provides social support to smokers (resource), so smokers feel being supported regardless of their backgrounds (e.g, gender) (reasoning)	O1: Smokers engage with social features within apps
2. Smokers view smoking cessation as a personal issue and do not seek social support, or they do not like socialising activities	M1: Apps provide social features (resource) but are not appealing to smokers (reasoning)	O1: Disengagement with social features
3. Smokers engage with social features within apps	M1: Smokers can always find other quitters situated in similar smoking cessation stage who share similar goals and barriers (resource) and they feel a sense of belonging and being understood (reasoning)  M2: Advanced quitters share experience of achieving long-term abstinence within social forums and may receive praise	O1: Smokers are motivated to stop smoking  O2: Advances quitters self-esteem boosted

	<p>from fellows (resource) and they feel they are helping others (reasoning)</p> <p>M3: Smokers learn quitting strategies from successful advanced quitters (resource) and believe they can apply these strategies to resist cravings and maintain abstinence (reasoning)</p> <p>M4: Smokers learn from failed experience to identify high-risk situations (resource) and become vigilant to relapse (reasoning)</p> <p>M5: Smokers share their quitting achievement within apps (resource) and create a positive sense of competition (reasoning)</p> <p>M6: Social features are poorly managed and regulated (resource), and smokers are demotivated by negative comments (reasoning)</p>	<p>O3: Smokers become more skilled and confident to stop smoking</p> <p>O4: More likely to resist cravings</p> <p>O5: Smokers are motivated to stop smoking</p> <p>O6: Decreased engagement with social features</p>
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Table 8.2: Summary of programme theory 2 (social support)

Social support within apps can be effective when it meets the needs of smokers who seek social support and perceive social support as useful (Shumaker and Brownell, 1984, Alqassim et al., 2022). This study found that Chinese smokers often face significant social isolation in their daily lives, caused by the social stigma associated with smoking and lack of support from people around them. Interview data also showed that social stigma associated with smoking often weighs more heavily on female smokers due to traditional cultural norms concerning women's roles and responsibilities in China. The social expectations on females can make it particularly

challenging for female smokers to seek and receive social support in real-life settings, as they may face harsher judgment compared to male smokers.

Online platforms, especially those within smoking cessation apps, offer a more neutral and inclusive environment because the diverse backgrounds in terms of reasons for smoking and smoking cessation, dependency levels, and personal traits such as gender are overshadowed by the collective goal of overcoming the addiction on nicotine and live independently of smoking. The social features of apps are specifically designed to facilitate social support for all users, including female smokers, allowing them to speak out about their challenges and experiences openly and benefit from this non-judgmental environment without the fear of stigma.

Except for the social stigma associated with smoking, Chinese smokers can always receive resistance to stop smoking in real life. First, their decisions to quit smoking may not be taken seriously by people around them due to various factors, including past failed attempts and the smoking culture in China, which regards smoking as a well-accepted way to establish relationships or show friendliness (Wang et al., 2014, Barnett et al., 2022). Furthermore, non-smokers may struggle to fully comprehend the challenges of smoking cessation, leading to a lack of empathy and understanding. This research also found that even among smoking peers, they may not take the smoking cessation decision seriously, either due to a perceived lack of necessity of smoking cessation or the belief that smoking cessation is an unattainable goal. Therefore, smokers who decide to stop smoking may lack social support in real life.

Experiencing social isolation in real life, including social stigma and lack of social support from other people, underscores the crucial role of social support features in smoking cessation apps (Li et al., 2024). This study found that social support features only work for smokers who seek social support during smoking cessation because they are more likely to engage with the social support features. However, the social support features may not work for smokers who view smoking cessation as a private matter, independent of social support or do not like socialising activities. As a result, social support features may not be appealing to them, leading to disengagement with social support features.

For smokers who face social isolation and seek social support through apps, the social features of smoking cessation apps can be effective by providing emotional support, informational support, and boosting self-esteem. The first type of social support is emotional support, which was mentioned most by participants in this study. Being a part of a social group that shares the same goal gives them a sense of belonging. Furthermore, since app users share the same goal and strive to quit smoking, they may also face similar barriers and challenges. Consequently, compared to people in real life, the quitting peers in apps are more likely to offer encouragement and show empathy to each other. This positive feedback loop motivates smokers to persist in their cessation journey because they feel being understood and supported.

The second type of social support is informational support from both successful and failed quitters. First of all, smokers will benefit from learning smoking cessation skills and experience from advanced quitters. Therefore, they will become more confident in keeping abstinence and skilled in managing cravings. When advanced quitters share their experiences, including how they have maintained abstinence for such a long time and the challenges they have faced before, it boosts their self-esteem as they feel they are helping others and often receive praise from fellow smokers. In addition to gaining insights from those who have successfully quit smoking, users can also benefit significantly from relapsed smokers. When relapsed smokers share their experiences that highlight the circumstances that led to their relapse, the sharing of failed experiences is also a valuable resource for smokers. This is because it helps current smokers to consider the possibility of facing similar challenges and identifying high-risk situations. Therefore, they become more prepared for these situations. At the same time, hearing about the regret and disappointment conveyed by relapsed smokers also is a lesson for smokers, which makes them more vigilant to relapse and more determined to resist cravings.

The last type of social support identified in this study was the sense of healthy competition, acting as a strong motivational force. When quitters share their achievements, such as the number of days they have remained abstinent, it may naturally inspire a sense of competition, which prompts smokers to strive to surpass

the achievements of their peers. The sense of competition is more prominent among those who start smoking cessation on the same day, as they share the same starting point and can see their peers dropping out of the 'battle' due to relapse.

This study identified an undesirable mechanism for the social support features. Although app developers specifically designed the social features for users to seek social support, if the social features are not managed and regulated well, particularly with regard to language governance, user engagement could suffer. Negative comments that convey negative attitudes towards smoking cessation may demotivate smokers to quit. Additionally, since the groups within apps are focused on smoking cessation, discussions should be highly relevant to quitting smoking, and off-topic conversations should be appropriately restricted. If most discussions in the group are unrelated to smoking cessation, it could reduce users' trust in the app and make it difficult for those seeking social support to find help.

Figure 8.4 shows the mind map of programme theory in relation to social support.

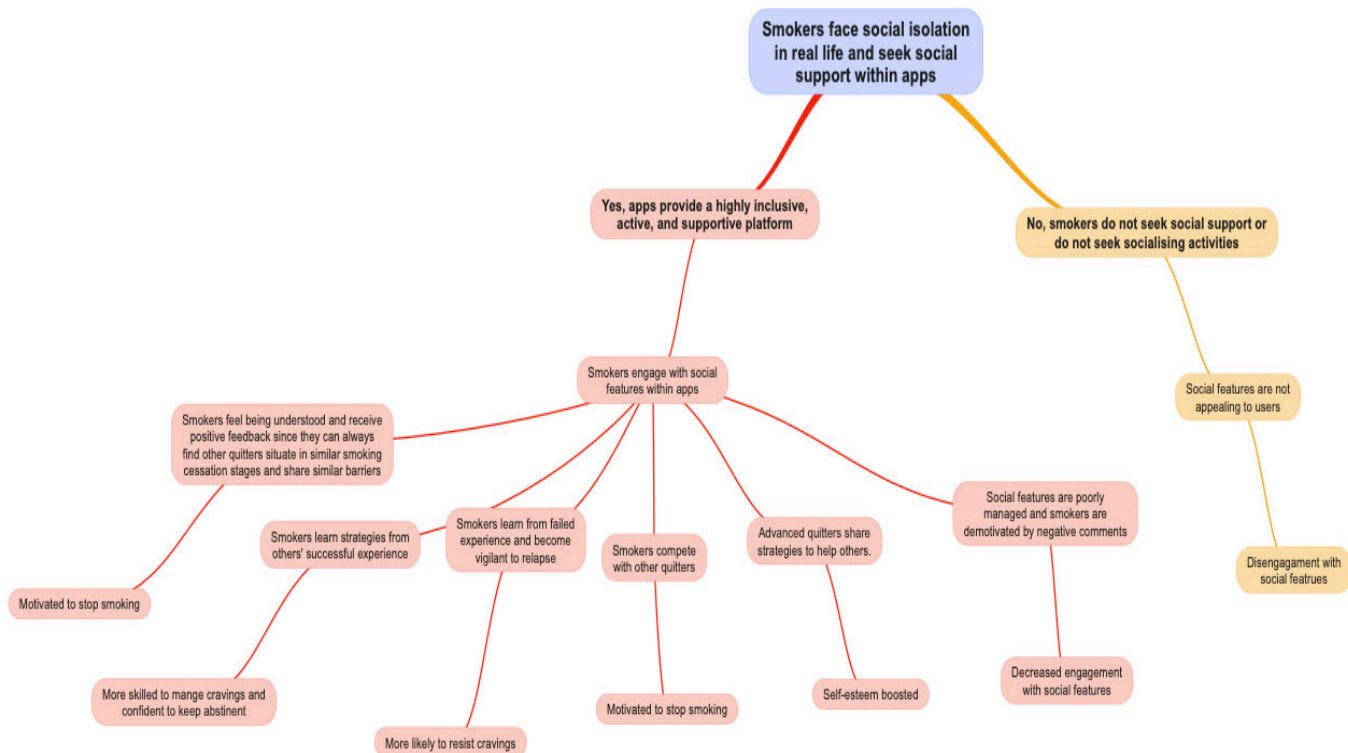


Figure 8.4: Mind map for programme theory 2, CMOC 1,2, and 3

In summary, social support features are essential in smoking cessation apps. However, for those who do not seek socialising activities or do not seek social support in smoking cessation, social support features are not appealing, and they are likely to disengage with them. The social support features are useful only when users seek social support during the smoking cessation journey. For smokers seeking social support within smoking cessation apps, the social support features provide informational support, emotional support, a healthy sense of competition, and also boost their self-esteem. This study also found that if the social support features are poorly managed and regulated, for example, allowing the existence of excessive negative comments and irrelevant topics, smokers may be demotivated to stop smoking rather than receiving social support as they desire, therefore reducing the engagement level with social support features.

#### 8.4 Refined programme theory 3: Relapse prevention

For smokers who expect to benefit from the withdrawal symptoms education feature and engage with it (context), apps can provide information on why withdrawal symptoms occur (resource mechanism), helping smokers feel less anxious about these symptoms (reasoning mechanism), which reduces craving triggers (outcome). However, if the management skills provided by the app lack personalisation or detailed guidance (resource mechanism), smokers may perceive this feature as useless (reasoning mechanism), leading to decreased engagement with the withdrawal symptoms education feature (outcome).

For smokers who engage with the withdrawal symptoms recording feature due to their open and realistic attitude toward cravings and their expectation of benefits (context), apps allow them to record their cravings (resource mechanism). This enables smokers to better understand their craving patterns (reasoning mechanism), helping them actively avoid high-risk situations or become more prepared to handle them (outcome). Additionally, smokers can record their real-time experience of withdrawal symptoms in apps (resource mechanism), allowing them to vent negative emotions (reasoning mechanism), which reduces relapse triggers (outcome). Moreover, apps allow users to track their cravings over time (resource mechanism),

providing smokers with a sense of control over their smoking cessation journey (reasoning mechanism). As a result, smokers gain greater confidence in their ability to quit smoking (outcome). Table 8.3 summarises the CMOCs in refined programme theory 3.

Contexts	Mechanisms	Outcomes
<p>1. Smokers expect to benefit from the withdrawal symptoms education feature and engage with it</p>	<p>M1: Smokers know why withdrawal symptoms happen through engaging with withdrawal symptoms education feature (resource) and become less anxious about it (reasoning)</p> <p>M2: The management skills provided by apps lack personalisation and further guidance (resource), so smokers perceive this feature as useless (reasoning)</p>	<p>O1: Reduced relapse triggers</p> <p>O2: Decreased user engagement with the withdrawal symptoms education feature</p>
<p>2. Smokers have an open and realistic attitude towards cravings, and they expect to benefit from the withdrawal symptoms recording feature, and engage with it</p>	<p>M1: Apps enable users to record their cravings (resource), including time, place, reason, intensity etc., so smokers will be clearer about their craving patterns (reasoning)</p> <p>M2: Apps enable users to record their real-time experience of withdrawal symptoms (resource), so smokers can vent their negative emotions (reasoning)</p> <p>M3: Apps enable users to record their cravings and smoker can see their cravings change over time (resource), so they gain a sense of control on smoking cessation (reasoning)</p>	<p>O1: Smokers avoid high risk situations or are more prepared to cope with them</p> <p>O2: Reduction in relapse triggers</p> <p>O3: Smokers become more confident to stop smoking</p>

Table 8.3: Summary of refined programme theory 3 (relapse prevention)

To prevent relapse, smoking cessation apps provide withdrawal symptoms education and recording features. The withdrawal symptoms education feature was intended to equip smokers with withdrawal symptoms-related knowledge, including the reasons why these symptoms can occur, how long they will last, and the skills to deal with them. Therefore, smokers will be more knowledgeable and skilled in coping with these symptoms. Interview data showed that only smokers who expect to benefit from this feature will engage with it. However, this study found that the engagement level of this feature was low as smokers found the provided educational information was not personalised, with low-intensity, and lacked further instructions. In the context of expecting to benefit from and engage with the withdrawal symptoms education feature and engage with it, the undesirable mechanism is the generic and low-intensity support provided by apps, leading to decreased user engagement. For example, when educating smokers on how to distract themselves from cravings, apps just provide textual suggestions, such as 'Do some exercise' rather than incorporating videos to guide smokers to do exercise.

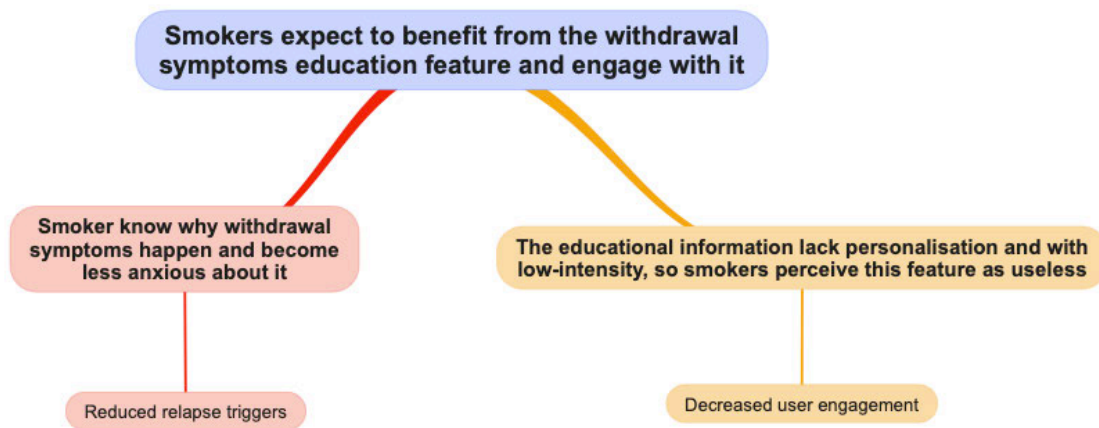


Figure 8.5: Mind map for programme theory 3, CMOC 1

The second feature to help smokers prevent relapse is the withdrawal symptoms recording feature. Interview data showed that only smokers who have an open attitude towards cravings and believe they can benefit from the withdrawal symptoms recording feature will engage with it. This study found that among interviewees who

regularly engaged with the craving recording feature, their attitudes towards cravings were open and realistic and viewed the ability to control cravings and the reduction in craving frequency or intensity as signs of smoking cessation progress. It indicates that smokers' open and realistic attitudes towards cravings increase smokers' expectations of the withdrawal symptoms recording feature. Therefore, these smokers will engage with this feature.

The desired outcome of the withdrawal symptoms recording feature in smoking cessation apps that allows users to journalise withdrawal symptoms was designed to serve as a way to help smokers become clearer about their craving patterns, so they can identify high-risk situations and be more prepared and vigilant to them. However, this desired outcome was only found among smokers who believe they can benefit from the recording feature.

It was interesting to find two unintended outcomes of the withdrawal symptoms recording feature. The first unintended outcome is that smokers vented the negative emotions caused by smoking cessation through journalising their experience with withdrawal symptoms, although this outcome was only observed in the smokers who had the pre-existing habit of keeping a record of their withdrawal symptoms. In other words, this outcome only happened to smokers who expected to benefit from this feature and were willing to engage with it. As long-lasting negative emotions can be a trigger for relapse (Robinson et al., 2019, Míguez and Pereira, 2021), venting negative emotions through journalising withdrawal symptoms can reduce relapse triggers.

Another unintended outcome was that smokers who engaged with the withdrawal symptoms recording feature gained a sense of control over their smoking cessation progress, thereby becoming more confident in their ability to quit successfully. Recording cravings allows smokers to go back to review the intensity and frequency change of their addiction, which is also one of the indicators of quitting smoking progress.

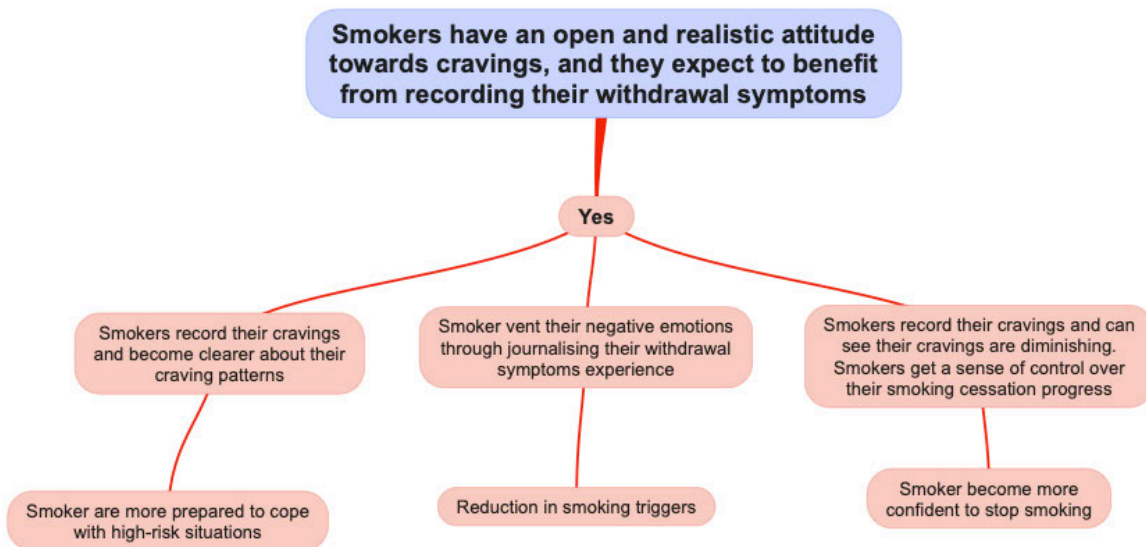


Figure 8.6 Mind map for programme theory 3, CMOC 2

In summary, when smokers expect to benefit from the withdrawal symptoms education feature, if the provided information is generic and with low intensity, the user engagement level will be quite low. App developers should note that providing personalised information and increasing the intervention intensity is important. The withdrawal symptoms recording feature only works for smokers who hold an open and realistic attitude towards having cravings and expect to benefit from this feature.

### 8.5 Refined programme theory 4: Sustained user engagement

For smokers who expect the apps to be usable (context), apps provide multiple media formats and personalised visual design (resource mechanism), so smokers could engage with different features intuitively, effectively, and with satisfaction (reasoning mechanism). Then smokers are more likely to engage with the apps (outcome).

For smokers who expect to have a positive user experience (context), if apps have reliable origins (resource mechanism), then smokers will believe their privacy and security data are protected and they can use strategies to protect their privacy (reasoning mechanism), then user engagement will not be affected by privacy and security issues (outcome). If apps provide the record keeping feature which allows

them to access their data whenever they reinstall the app (resource mechanism), smokers will find this feature satisfying (reasoning mechanism), increasing the likelihood of long-term engagement with the app (outcome). When apps provide gamification features (resource mechanism), smokers will feel the smoking cessation journey more enjoyable and their achievements visible (reasoning mechanism), leading to increased user engagement on gamification features (outcome). When apps have advertisement (resource mechanism), smokers view watching advertisements as trade-off for using the app freely and they are tolerant to advertisements (reasoning mechanism), so user engagement will not be influenced by advertisements (outcome). In contrast, when apps have premium features that need payment (resource mechanism), smokers will be dissatisfied with it because of the low perceived value of apps (reasoning mechanism), then user engagement on the premium features will be limited (outcome). When app features lack personalisation and cannot meet smokers' diverse needs (resource mechanism), and smokers perceive low usefulness of these features (reasoning mechanism), user engagement with features that lack personalisation will decrease (outcome). Table 8.4 presents the CMOCs in programme theory 4.

Contexts	Mechanisms	Outcomes
1. Smokers expect the apps to be usable, so they can use the apps to help them stop smoking effectively, efficiently, and with satisfaction	M1: Apps provides multiple media formats and personalised visual design (resource), so smokers can engage with different features intuitively (efficiently) and choose their preferred visual design (satisfaction), and also use different media formats to meet their needs (effectively) (reasoning)	O1: Smokers are more likely to engage with the apps
2. Smokers expect to have a better user experience when using the apps	M1: Smokers believe their privacy and data security are protected or they use strategies to protect their privacy (reasoning) because apps are from official app stores (resource)  M2: Smokers are satisfied (reasoning) with the record keeping feature because it allows	O1: User engagement not affected by privacy and security issues

	<p>them to access historical data whenever they download the app again (resource)</p> <p>M3: Apps provide gamification features (resource) and smokers feel the smoking cessation journey more enjoyable and achievements visible (reasoning)</p> <p>M4: If apps have advertisement (resource), smokers view watching advertisements as trade-off for using the app freely and they are tolerant to advertisements (reasoning)</p> <p>M5: If apps have premium features (resource), smokers who perceive low value of apps are dissatisfied with the premium features that need payment (reasoning)</p> <p>M6: App features lack personalisation and cannot meet smokers' diverse needs (resource), and smokers perceive low usefulness of these features (reasoning)</p>	<p>O2: Smokers are more likely to engage with the app in the long-term</p> <p>O3: Increased user engagement on gamification features</p> <p>O4: User engagement not influenced by advertisements</p> <p>O5: Limited engagement with premium features</p> <p>O6: Decreased user engagement with features that lack personalisation</p>
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Table 8.4: Summary of programme theory 4 (sustained user engagement)

This programme theory is mainly about how usability and user experience affect user engagement levels. Interview data showed that smokers expect the apps to be more usable so they can engage with the apps to stop smoking more effectively, efficiently, and with satisfaction. The ease-of-use attribute allows smokers to engage with different app features intuitively and efficiently, without confusion. In addition, this study found smokers have diverse needs in terms of how they access resources within apps. For example, when accessing short pieces of information, they would prefer a textual format. However, when displaying the risks of smoking, images may

have a greater visual impact and can strengthen their motivation to quit smoking more effectively than textual descriptions. Interview data also showed that smokers have different preferences in terms of visual design elements. Thus, providing personalised style settings allows smokers to engage with the apps with satisfaction.

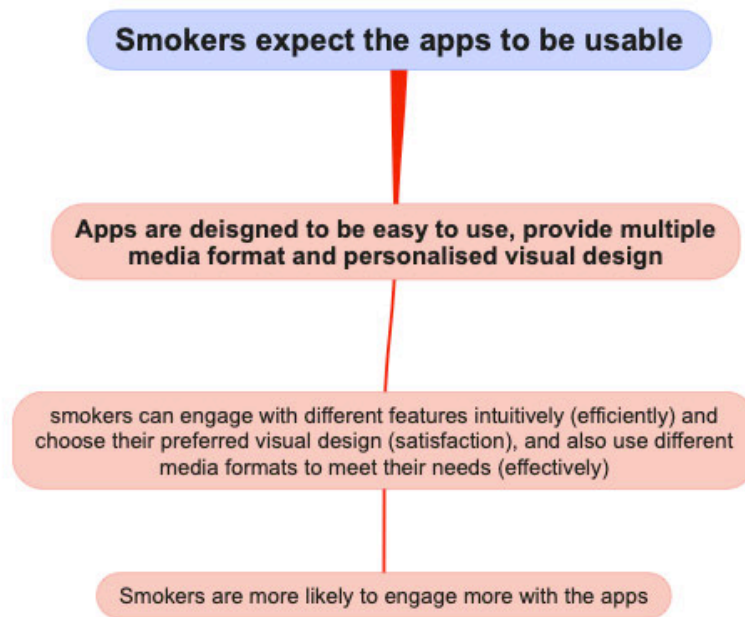


Figure 8.7 Mind map for programme theory 4, CMOC 1

Interview data showed that user experience design could affect user engagement levels. It was interesting to find that smokers were not worried about their privacy and security issues if the apps were downloaded within official app stores or if they believed their privacy and security could be protected using their evolved strategies, such as using the anonymity feature. For these smokers who believed their privacy and security were protected well, their engagement level will not be affected by this issue. However, it is possible that Chinese smokers' trust in institutions such as official app stores is misplaced or that their privacy protection strategies are insufficient. Although this study found that user engagement levels were not affected by privacy and security concerns, app developers should still fully consider user data protection issues and explicitly explain the privacy terms to users before they start using the app.

This study found that the record-keeping feature was important for long-term engagement. As found in theme 3 (self-efficacy), smokers will decrease their engagement levels with apps when they believe in their abilities to stop smoking. However, since relapse is common in the process of quitting smoking (Marlatt and Gordon, 1985, Melemis, 2015), smokers may download the app again and continue using its features to help them quit smoking. Interview data found that if smokers discovered that their previous data was still saved, they were more likely to continue using the app they used before, as they wanted to see their historical quitting data.

The gamification features were effective in boosting user experience and making the smoking cessation journey more enjoyable. For example, the achievement system, such as the rank system, made smokers' achievements visible. Smokers who found the apps enjoyable to use will be more likely to engage with these gamification features.

Interview data showed that advertisements and the membership fee affect user engagement levels differently. In this study, smokers viewed watching a few seconds of advertisements as the trade-off for using the app for free. Therefore, they were highly tolerant of advertisements, and they did not affect their user experience and engagement level on the apps. In contrast, smokers who perceived the low value of smoking cessation apps were dissatisfied with the membership fee, which negatively affected the user engagement level of these premium features.

Lastly, although personalisation was expected by interviewees, smokers denied that the apps had provided personalised features. For smokers who seek support within apps but cannot receive support to meet their needs due to the lack of personalisation, their user experience will be negatively affected. Therefore, the engagement level of the features that lack personalisation will decrease.

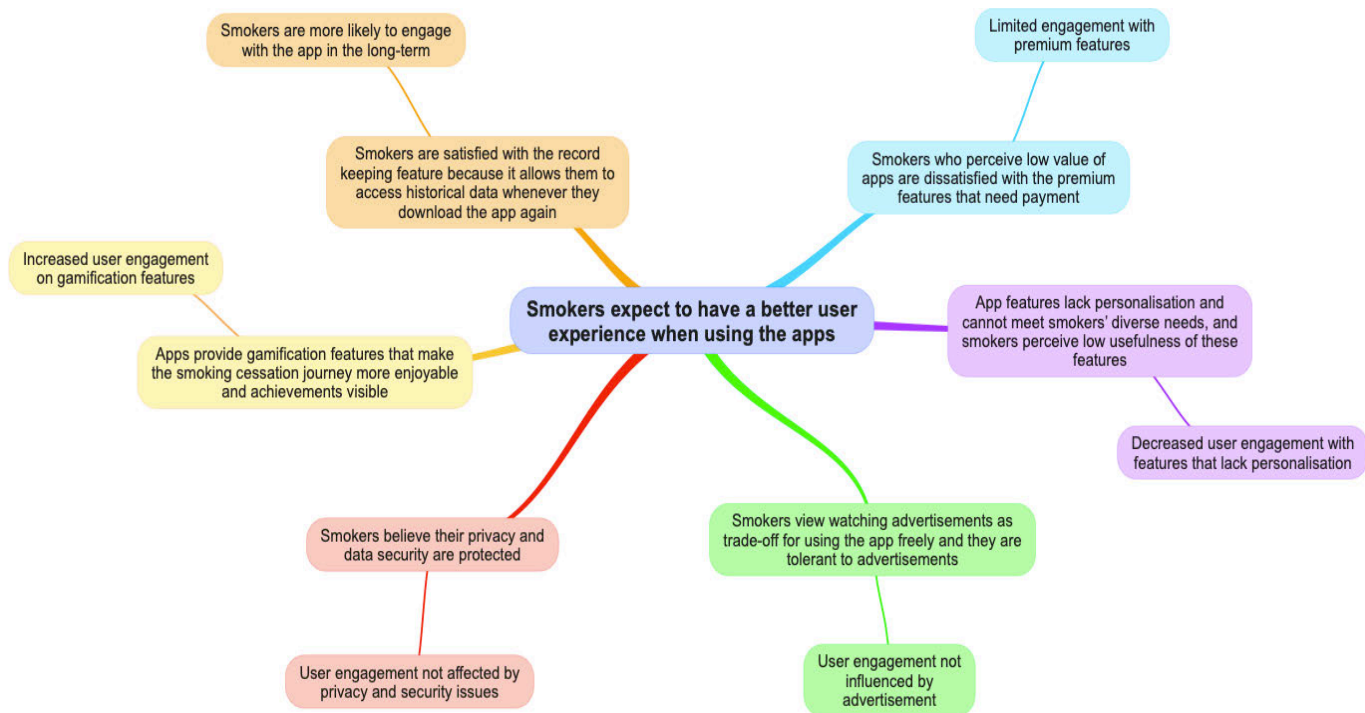


Figure 8.8 Mind map for programme theory 4, CMOC 2

In summary, smokers expect smoking cessation apps to be more usable. Smoking cessation apps that are easy to use and provide multiple modalities and personalised interface design allow users to engage with the apps effectively, efficiently, and with satisfaction. Smokers' experience of using the apps to quit smoking was linked with user engagement levels. This study found the recording-keeping feature was effective in increasing long-term user engagement levels for smokers who expect to access their historical quitting smoking data. For quitting smoking, which requires long-term commitment and may involve multiple attempts, the record-keeping feature is essential. Whether advertising and membership fees affect user experience depends on whether users perceive them as valuable. For smokers who perceived the advertisements as a trade-off of using the app for free, their engagement level was not affected. However, membership fees dissatisfied smokers who perceive smoking cessation apps as less valuable and believe smoking cessation mainly depends on an individual's efforts. Despite smokers expecting smoking cessation apps to provide personalised support to meet their varying needs, they found the personalisation features of the apps to be unsatisfactory. Therefore, the user engagement level was negatively affected.

## CHAPTER NINE: Discussion

### 9.1 Introduction

This last chapter outlines the contributions of this study to knowledge, reflexivity, the strengths and limitations of this research, and implications for future practice and research. When deciding on the format for writing the contributions to knowledge, I initially considered using the research questions as subheadings. However, since each programme theory emphasises different aspects of contexts, mechanisms, and outcomes, introducing various contexts, mechanisms, and outcomes under separate subheadings could lead to confusion. Moreover, considering that it is difficult to explain intended and unintended outcomes without the introduction of context-mechanism interplay, I finally decided to articulate the contributions under important areas of the programme theories.

### 9.2 Contributions to knowledge

The overall aim of this study was to examine what aspects of smoking cessation apps work for Chinese smokers, under what circumstances, and why. This evaluation starts with the identification of IPTs about how smoking cessation apps help Chinese smokers stop smoking through two systematic reviews (Chapters 4 and 5) and interviews with Chinese health workers (Chapter 6). Four IPTs were formulated: boosting motivation and self-efficacy, social support, relapse prevention, and sustained user engagement. The first three IPTs were about how smoking cessation apps achieve their desired outcome of helping smokers stop smoking, and the last IPT was about how different aspects of smoking cessation apps affect user engagement levels. To start theory testing and refinement, each IPT was formulated into CMOCs and 'if...then...because...' statements (Chapter 6).

Overall, the findings of this research are consistent with previous research, demonstrating that smoking cessation apps can assist motivated smokers in stopping smoking by boosting their motivation and self-efficacy (Rajani et al., 2021a), providing social support (Smith et al., 2017, Granado-Font et al., 2018), and providing educational knowledge, as well as keeping a record of withdrawal symptoms, including cravings (El-Hilly et al., 2016, Herbst et al., 2020).

Lastly, this study found different aspects of usability and user experience design affect user engagement levels, which is also consistent with a previous literature review (Garett et al., 2016). User engagement level is an important influencing factor in the success of mHealth interventions (Borghouts et al., 2021), although whether a higher user engagement level could lead to better health outcomes is still a debate. The relationship between the user engagement level of smoking cessation apps and their effects on smoking cessation outcomes was explored by previous research. For example, Bricker (2021) found that the effect of the iCanQuit app on smoking cessation was influenced by various indicators of user engagement, such as the number of logins, number of days of use, etc. However, not all previous research supports the idea that user engagement can be directly related to better smoking cessation outcomes. For example, Smith et al. (2017) found productive disengagement and counterproductive engagement can both exist during the use of smoking cessation apps. In this study, smokers with high efficacy levels tend to decrease engagement levels but still persist in smoking cessation. In such cases, user engagement levels cannot be directly linked with smoking cessation outcomes, such as abstinence days.

The following sections discuss the key findings of this study to explain what contextual factors and mechanisms interact with each other to cause the success or failure of smoking cessation apps.

### 9.2.1 Motivations for short-term and long-term abstinence

The results of this evaluation suggest that smoking cessation apps only work for smokers who are motivated and believe in the effects of smoking cessation apps. This finding was consistent with previous research on the transtheoretical model, which found that individuals in the preparation stage should be the target population and can benefit more from behaviour change interventions (Prochaska, 2008). If smokers are not motivated to stop smoking, or if they do not believe smoking cessation apps could be effective tools, they will not choose to use apps, or user engagement could be counterproductive. Through app features that show the benefits of smoking cessation, such as health gains and financial savings, etc.,

progress of quitting smoking, such as abstinence days and rank system, etc., and educate the risks of smoking, smokers' extrinsic and intrinsic motivation could be boosted. In addition, smokers' self-efficacy will be boosted through the accumulation of quitting achievements and progress. Although smoking cessation apps provide a diversity of components showing smoking cessation gains and progress, which app features engage smokers more depends on users' specific needs. Therefore, it is important to design various app features to show quitting progress and gains to boost smokers' motivation, considering that smokers' needs can be distinct.

Specifically, this research found that both intrinsic and extrinsic motivation play a role in helping smokers make the decision to continue with abstinence. The findings of this research also indicate that intrinsic motivation has a longer-lasting effect compared to extrinsic motivation. The key driving force that continuously encourages smokers to quit smoking is their intrinsic motivation, which is the understanding of the benefits of quitting smoking and the risks of smoking. This finding echoes previous studies that smokers with a higher level of intrinsic motivation are more likely to quit smoking successfully compared to those primarily driven by extrinsic motivation (Curry et al., 1990, Choi et al., 2014). Another study also found that after a 12-month follow-up, even though financial incentives increased the use of intervention, they did not improve the abstinence rates among smokers (Curry et al., 1991). App features that enhance intrinsic motivation are crucial as they solidify smokers' determination to quit, allowing them to continue their efforts to quit smoking even without external incentives or the use of the app, which is vital for long-term success in quitting smoking.

This study also found that self-efficacy plays a vital role in long-term abstinence. The effect of self-efficacy in behaviour change is confirmed by research evidence over decades (Bandura and Adams, 1977, Bandura and Wessels, 1994, Gwaltney et al., 2009). When smokers are more confident in their ability to quit smoking successfully, they are more likely to persist in smoking cessation in the long term. Smoking cessation apps provide extrinsic motivation, such as tracking quitting progress, which acts as a key factor in enhancing self-efficacy. When their quitting achievements and capabilities are confirmed by various data displayed in the app, their self-efficacy is boosted. Overall, while the extrinsic motivation provided by the app attracts smokers

to use the app and persist in smoking cessation in the short term, these extrinsic incentives can enhance smokers' self-efficacy, which also plays a role in long-term abstinence.

Drawing on the self-determination theory (SDT) can help to understand and explain the first programme theory about how smoking cessation apps provide cognitive support to assist smokers in stopping smoking (Chapter 2). SDT focuses on the three psychological needs when striving for personal goals, namely autonomy, competence, and relatedness (Deci and Ryan, 2013, Ryan, 2023). The psychological need for autonomy explains why smoking cessation apps are only effective for those who are already motivated to quit smoking, which is an important contextual factor for the success of smoking cessation apps. If smokers lack autonomy, for example, if they are quitting under external pressure, then the use of apps may backfire. For those who are not autonomously quitting or not considering quitting at all, the presence of the app might produce an unintended consequence by reminding them of how many days they have left cigarettes, which could trigger stronger cravings to smoke. What the app can do in this regard is to reinforce the dangers of smoking and the benefits of quitting, thus motivating them to make autonomous decisions to stop smoking. App features that nurture extrinsic motivation meet the psychological need for competence. App features that track progress, such as the number of abstinence days, money saved, and health recovery, as well as gamification features like reward systems and rank systems, all play a role in enhancing the smoker's sense of competence.

### 9.2.2 Positive and negative information

As introduced in Chapter 2, Protection Motivation Theory (PMT) suggests that behaviour change is influenced by two pathways, namely the threat pathway and the coping pathway (Rogers, 1975). In the context of smoking cessation, the threat pathway involves smokers' consideration of the severity and vulnerability of smoking, along with the perceived benefits they get from smoking, such as temporary pleasure or social connections. The coping pathway, on the other hand, refers to the benefits of smoking cessation, perceived self-efficacy, and the costs associated with quitting smoking, such as failing to smoke to alleviate stress or maintain social connections.

The consideration of both pathways influences smokers' decision to quit. The 'carrot and stick' motivational approach is often employed by smoking cessation apps to combine an emphasis on the risks of smoking and the benefits of smoking cessation (Volpp and Galvin, 2014, Mahmoodi et al., 2018).

However, this study found that positive stimuli were more attractive to smokers, such as the benefits of quitting smoking, compared to negative stimuli, such as the risks of smoking. This finding is consistent with previous research findings (Paay et al., 2014, Edwards et al., 2018, Schick et al., 2018, Luna-Perejon et al., 2019, Struik et al., 2019). For instance, Edwards et al. (2018) found that smokers preferred apps to focus more on positive emotional content to promote relaxation and happiness during smoking cessation. Although app developers design smoking cessation apps that leverage the strengths of both pathways to motivate smokers to quit, the use of negative stimuli should be carefully considered due to potential unintended outcomes that trigger cravings. The research findings indicate that while positive stimuli benefit most app users, negative stimuli should be employed with caution because smokers have different backgrounds and knowledge levels of the risks of smoking. For example, if smokers inherently dislike receiving negative feedback, frequent negative information may backfire, triggering negative emotions such as fear and anxiety, which can be a significant risk factor for future smoking behaviour (Yan et al., 2019). App developers should consider providing personalisation in terms of functionality (Romeo et al., 2019), for example, giving users the autonomy to choose which information they prefer to receive rather than overwhelming users with considerable unsolicited information.

### 9.2.3 Fight alone or embrace social support

Social support is defined as beneficial interactions between support providers and recipients that help someone reduce uncertainty about the situation and enhance a sense of control over their experiences (Albrecht and Adelman, 1987). This study found that experiencing social isolation, including social stigma and a sense of loneliness (Chapter 7), is the contextual factor for the success of social support features. Smokers may face social isolation and lack social support in real life because non-smokers or smokers who are not motivated to stop smoking cannot

fully understand their smoking cessation journey and empathise with them. Therefore, they seek social support from other quitting peers in smoking cessation apps.

According to SDT (Deci and Ryan, 2012b), the third psychological need of smokers when striving for long-term abstinence is relatedness. However, this study found that not all smokers are keen to receive social support during smoking cessation. The reasons why they perceive social support as unnecessary can be rather complicated. First, smokers are individuals with diverse personalities (Roccas et al., 2002), and preferences for types of assistance (Owen and Davies, 1990). In addition, this study found that the acceptance level of social support is also linked with past quitting experiences and smokers' background. For example, smokers who have sought social support from their friends to stop smoking but failed will be demotivated by this experience to rely on social support for smoking cessation in the future. This indicates that social support is not universally effective but rather depends on the specific circumstances of different smokers.

This study found that smokers who do not like socialising activities or do not seek social support in smoking cessation are less likely to engage with social support features. This finding is consistent with previous research, which suggested that social support is most effective when it matches the needs and preferences of people who require it and it is perceived as useful and effective by these individuals (Shumaker and Brownell, 1984, Cutrona and Russell, 1990).

Social support covers different domains. The exact number and definition vary between authors. For the purpose of this study, I distinguish between five types of social support: informational support (offering suggestions, guidance, information, and feedback), emotional support (showing empathy, encouragement, and understanding), esteem support (offering affirmation and respect), network support (providing social connections and interactions), and tangible support (providing, practical help, such as financial assistance) (Cobb, 1978, Schaefer et al., 1981, Barrera, 1986, Cutrona and Russell, 1990, Westmaas et al., 2010, Alqassim et al., 2022). This research identified informational support, emotional support, and esteem support from the social features of apps. However, network support and tangible

support were not found in the interview data with smokers. The possible reason is that users lack sufficient trust in other smokers they met on online platforms or they are concerned about personal information and privacy.

Informational support in smoking cessation indicates that smokers provide information on how to deal with different situations regarding smoking cessation. It can include how to deal with cravings and skills to manage withdrawal symptoms (Westmaas et al., 2010). In this study, smokers can receive informational support through learning quitting strategies from experienced quitters and being alert to high-risk situations by knowing the failed experiences of relapsed smokers. Emotional support in smoking cessation indicates providing emotional feedback, such as encouragement, understanding, and empathy, to other smokers (Westmaas et al., 2010). In this study, smokers provide emotional support to each other by showing empathy and understanding and sharing their similar experiences on social platforms within apps. Another type of social support identified in this study was esteem support, which existed among successful quitters who shared their experiences with other smokers and were regarded as 'role models' by other smokers, thereby boosting their self-esteem.

It was interesting to find that smokers who were situated in a social group where group members share the same goal of pursuing abstinence, for instance, will automatically get a sense of healthy competition to motivate them to remain abstinent. This finding was consistent with a previous study, which found that competing with other quitters to stay smoke-free for a longer period was highly motivational (Paay et al., 2015b). The effects of competition have been discussed by other research over decades (Deci et al., 1981, Tauer and Harackiewicz, 2004, DiMenichi and Tricomi, 2015). Tauer and Harackiewicz (2004) found competition boosts performance and intrinsic motivation, while in Deci et al. (1981), competition is regarded as extrinsic motivation in nature and can shift attention from the task itself, thereby decreasing intrinsic motivation to the target activity, such as smoking cessation. DiMenichi and Tricomi (2015) found competition is effective in physical activities but not in memory activities. Overall, the effects of competition are complex and multifaceted. While competition can potentially boost motivation and performance, it may also lead to a shift in attention to the target activity. Therefore,

when introducing a competition mechanism in a smoking cessation app, it is necessary to ensure that the competition mechanism does not interfere with the target goal of quitting smoking. Although competition is not traditionally included in the types of social support, this study found that the positive competition generated during the use of social support features can motivate smokers to stay abstinent, even though the sense of competition is not the primary goal of the social features.

This study also found that poorly managed and regulated social support features will lead to decreased user engagement on these features. To ensure the positive effects of social features within apps, it is crucial to implement robust management practices. Therefore, app developers should consider two things. Firstly, implement language management strategies to keep the social group atmosphere positive and supportive, possibly by developing features that allow users to block posts they find negative. Secondly, implement topic management to maintain the focus of the social groups within the app, which might be achieved through reminders by system administrators that this is a group for quitting smoking.

#### 9.2.4 Relapse prevention

The relapse prevention features mainly include educating smokers on tips to manage withdrawal symptoms and recording them within apps. The study findings showed that the user engagement level with the withdrawal symptoms education feature was low because the provided information lacked personalisation and practicality. This finding echoed previous research that explored the effectiveness of relapse prevention interventions in smoking cessation. Lancaster et al. (2006) conducted a systematic review to assess whether relapse prevention interventions were effective in decreasing the rate of relapse after a successful quitting attempt. This systematic review found that behavioural interventions that incorporated skills training to identify and resolve high-risk situations to manage cravings were not effective. The authors suggested that the possible reason was that most included interventions had low intensity, such as only providing written materials, mailings, etc., which were less likely to produce significant effectiveness in preventing relapse.

The current study identified two possible reasons for the low engagement of withdrawal symptom education features. The first possible reason was the mismatching between user needs and the feature. In this study, when smokers believed they did not benefit from the skills to overcome withdrawal symptoms, this feature remained mismatched with user needs, leading to a low engagement level (Chapter 7). For example, some smokers felt that cravings pass quickly, and seeking help from apps was unrealistic and meaningless during this brief period. The second reason for the low engagement level was the low-intensity and non-personalised support provided by apps. When smokers decide to use the withdrawal symptoms education feature, their engagement level decreases if they find the provided information lacking personalisation and practicality (Chapter 7).

In this study, the withdrawal symptom recording feature worked for smokers who held an open and realistic attitude towards cravings and believed they could benefit from recording their cravings. Previous studies also emphasised the importance of accepting having cravings as a normal part of smoking cessation. For example, mindfulness-based smoking cessation interventions aim to increase smokers' awareness of their cravings by observing thoughts, emotions, and sensations when cravings arise (Maglione et al., 2017, Oikonomou et al., 2017).

For smokers who are unfamiliar with their smoking patterns, documenting cravings can help them identify high-risk situations and develop appropriate strategies (Bendotti et al., 2022). Meanwhile, for those who are keen to track changes in their cravings, maintaining a record and observing a decline in craving frequency or intensity can boost their confidence in managing cravings and maintaining abstinence. Previous research also posed evidence that viewing cravings frequency decrease within apps can produce pleasure among smokers (Armin et al., 2017).

#### 9.2.5 Sustained user engagement

This study found that usability and user experience design are linked with user engagement levels. Good usability and positive user experience can predict higher user engagement levels, helping smokers interact with apps more effectively, efficiently, and with satisfaction.

The findings of this study indicated that usability could improve through ease of use, providing different media formats and visually appealing interfaces that allow customisation to meet different user needs, and considering different user needs to increase accessibility. This finding was consistent with previous research, which also found that simplicity, graphical representations, readability, etc., are essential design elements for higher user engagement (Naumann, 2008, Garrett et al., 2016).

Moreover, this study found that users had a positive user experience when apps were more enjoyable and made them feel they were safe and their privacy was protected. Although users expected safe and privacy-protective apps, their awareness of privacy protection did not seem high. They often underestimated the capabilities and possibilities of online information theft. Previous research has confirmed that user experience can be improved by having anonymity features or allowing virtual avatars or profile photos, which makes users trust the app more, thereby increasing user engagement level (Kang et al., 2013).

When asked which aspects of smoking cessation apps affected user experience, smokers most frequently mentioned the impact of advertisements and membership fees. Although past research has found the negative impacts of advertisements on online interventions, such as reducing usability or causing negative emotions (Brajnik and Gabrielli, 2010), this study found that smokers have a high tolerance for advertisements included in smoking cessation apps. This may be because they view watching advertisements as a trade-off for using apps for free, and advertisements are generally short, allowing users to "skip" after a few seconds. However, this study found that app features which required membership fees would negatively affect user experience, therefore, reducing user engagement level on these paid features.

Lack of personalisation was another factor that negatively influenced user experience in this study. Interestingly, there is a discrepancy between the findings of this study and previous research regarding the personalisation characteristic. The qualitative systematic review in Chapter 4 (Zhang et al., 2023) found that amongst some studies, smokers liked personalised features. However, when asked in which directions apps could improve, few interviewees mentioned enhancing personalised

features. This discrepancy may be because smokers had low perceived usefulness of smoking cessation apps and did not expect them to provide personalised features or because smokers were not aware of the potential benefits of personalised features, leading them to underestimate the significance of personalisation.

### 9.3 Reflexivity

This research is a realist evaluation using qualitative methods. Qualitative research is contextual (Ritchie and Lewis, 2003). If qualitative researchers describe the contextual relationships between the research elements, such as participants, place, time, etc., and themselves, the credibility of qualitative research is increased (Watt, 2007). To ensure the rigour and quality of the qualitative research, it is the researcher's responsibility to clarify all self-knowledge, personal beliefs, past experiences, and potential biases that can have an impact on the research (Dodgson, 2019). Reflexivity is a concept that has been used for over a century, which not only improves the credibility of the research findings but also deepens readers' understanding (Mitchell et al., 2018). Reflexivity is the process in which researchers critically reflect on themselves, recognising their influence on the research topic and participants and how the research experience impacts them (Malterud, 2001, Dodgson, 2019). Since qualitative research was developed based on the interaction between the researcher and participants., I self-reflected this research in several aspects, including recruitment, data collection, data analysis and interpretation (Finlay, 2002).

In realist evaluation, to formulate and test IPTs, interviewing different stakeholders is common to gain their insights on how the intervention works (Westhorp et al., 2011). During the first stage of formulating IPTs, along with the two systematic reviews, I conducted interviews with Chinese health workers who were working in a smoking cessation clinic and respiratory departments in two hospitals (hospital A in an urban city and hospital B in a rural city). All institutions that allowed me to recruit participants were accessed through my social or academic connections. One of my undergraduate professors introduced Hospital A to me. The professor also introduced me to the smoking cessation clinic, which had cooperations with hospital

A. The other hospital B, which is located in a rural city, also agreed for me to recruit participants in their hospital through my social connections.

I self-reflected that although the recruitment process was conducted by myself, the recruited health workers might know that I knew someone they had connections to. This has some advantages for the research because they can fully trust that I am a PhD student from a legitimate institution and that my research was strictly adhering to ethical requirements, which perhaps gave them reassurance to participate in my interviews. However, this indirect social relationship was also of concern to me as I worried that they would say what they thought I wanted to get. To avoid this, as part of the recruitment process, I sent them an electronic information sheet and explained the purpose of the research to them, emphasising that their genuine thoughts are crucial to the research. I also briefly introduced that both positive and negative comments on smoking cessation apps were valuable. During the interview process, I often emphasised the purpose of this research and encouraged them to be honest and talk about their opinions openly because the data was going to be anonymised.

Recruiting smokers via online social media offered several advantages. Firstly, participants came from different regions across China, and secondly, it increased the possibility of recruiting participants using a range of smoking cessation apps, which might increase the richness of data. However, online recruitment also has some challenges. For example, it was essential to build their trust in me and my research. Therefore, I included all research details in the information sheet, including the research aim, participants' rights and obligations, and how the collected data would be used and protected, etc. When potential participants showed interest, I first introduced myself as a PhD candidate from the University of Edinburgh and showed my student card to build their trust in me, followed by sending them the electronic information sheet and consent form if they were willing to take part.

This research generally aimed to explore how smoking cessation apps help smokers stop smoking. I am a non-smoker and have not used any smoking cessation apps before, but I have used other types of behaviour change apps, such as an app for tracking fasting times. In addition, since IPTs were formulated from existing literature, it was challenging to refrain from incorporating my pre-understanding of

how smoking cessation apps might work based on my past experience of using health apps and the existing behaviour change concepts and theories (Krefting, 1991). To prevent my pre-existing views from influencing the interview process, I used semi-structured interviews to give participants space to express their own opinions and modulated the IPTs formulated in stage one to be used in the interview guide with smokers by removing some specific details instead of presenting smokers with beautifully crafted and insightful CMOCs (Pawson and Tilley, 1997b). The modulation of IPTs to form the realist interview questions was advantageous (Manzano, 2016). First, it gave participants some space to fill in the gaps and contributed more causal insights, and secondly, it minimised the influence of my opinions on their responses since the way I phrased interview questions inevitably guided their responses.

In the testing stage, I conducted interviews with Chinese smokers, with the transcription of interviews from smokers interviewed earlier as well as later interviews occurring simultaneously. This means that as the interviews progressed, I gradually became more familiar with how smoking cessation apps help smokers quit. In qualitative research, the way researchers subjectively comprehend and interpret the data can impact the study's credibility and reliability (Noble and Smith, 2015). In this PhD project, I was the data collector and also the data analyst, which could potentially lead to bias influenced by my subjective thoughts (Miles and Huberman, 1994). To address this issue, I checked my understanding of previous smokers' meanings by presenting them to the following interviewees. For example, as interviews progressed, I had a sense that smokers who reduced engagement with apps might have gained strong self-efficacy to stop smoking. In the following interviews, I asked the interviewees, 'Previous participants said they will not use the app anymore if they believe they are confident enough to keep abstinent without the help of apps. What do you think about it?'

Considering the impact of Covid-19 at that time, it was difficult to meet participants from different regions in person. Thus, online interviews were deemed appropriate. To improve the quality of the collected data, I tested the Internet before entering the formal interview process in case a poor Internet connection influenced the interview process (de Villiers et al., 2022). To reduce the sense of disconnect of participants, I

used a casual tone to ask about their daily lives during formal interview processes. Furthermore, to build rapport with them, I also reminded them to move beyond the formalities of interviewer and interviewee and have a friendly conversation.

During the data analysis stage, I always self-reflected whether the interpretation was centred on the interviewees' views or experiences. Data analysis reports with selected quotes were also regularly sent to the supervision team to check the accuracy of interpretation. When the supervision team was skeptical about the findings, I went back to the original transcripts to interrogate a wider scope of what the interviewee said to accurately understand participants' meanings.

Interviews with smokers could only be undertaken using Mandarin because English is not one of the official languages in mainland China, and Mandarin is the standard language across different regions of mainland China (Mandarin is also my mother tongue). Therefore, translating transcripts into English for data analysis could lead to a lack of comprehensive understanding or misinterpretation of the interviewees' genuine meanings (Temple and Young, 2004, Squires, 2009). After a discussion with the supervision team, I decided to analyse the transcripts in the original language and only translate selected quotes into English in this thesis. To ensure that the English translations of the quotes retain their original meaning, the words in English were carefully chosen. When ambiguities arose, I used a bilingual dictionary to check the meanings of specific English words to determine whether to replace them with another word.

## 9.4 Strengths and limitations of this research

### 9.4.1 Strengths of this research

Throughout the whole research progress, transparency was guaranteed through clearly recorded and reported details to the supervision team, ensuring a high level of clarity and accountability. To ensure the rigour of this PhD research, several measures were undertaken.

Firstly, the literature reviews adhered closely to the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2022), with each phase of the review process being thoroughly discussed with and agreed upon with the supervision team. Expert assistance was sought to guarantee comprehensive and systematic literature searches, including consultation with the librarian in the School of Health in Social Science at the University of Edinburgh. Secondly, before field interviews started, this research obtained ethical approval and a sponsorship letter from the University of Edinburgh (Appendix 1 and 10) and maintained strict adherence to these ethical guidelines throughout the research process. Thirdly, before starting the interviews, I had a practical session with another doctoral student who was experienced in realist interview techniques to strengthen my interviewing skills. Fourthly, to thoroughly understand how to collect, analyse, and interpret data in realist evaluation, I attended realist evaluation methodology training and presented my work at a realist conference to gain other realists' feedback. I also extensively searched realist evaluation studies published in the past five years, identifying commonalities and limitations and considering which data analysis method was suitable for this research. This exercise influenced my choice of content thematic analysis as a data analysis method for this study. Last but not least, in stage one, IPTs were formulated and presented in both CMOCs and narrative 'if...then...because' descriptions to ensure each IPT was thoroughly conceptualised.

The flexibility of semi-structured interviews also benefits this study, which aims to explore the contexts, mechanisms and outcomes of using smoking cessation apps. It not only allows the use of previously formulated IPTs to shape the interview guide through realist interviewing but also enables the exploration of deeper insights based on the interviewee's answers to gather richer data. For example, when a smoker mentioned that he used to engage with the daily check-in feature in the app during the first year of using it, but he rarely opened the app to check in now, although he still kept abstinent, semi-structured interviews allowed me to ask follow-up questions to clarify the context or reasoning behind this response (Maxwell, 2012a). This is very important for realist evaluation studies, as interviewees sometimes only report the outcomes after using the intervention, but the contexts and mechanisms that produce these outcomes often require deeper exploration by the interviewer (Pawson and Tilley, 1997b).

#### 9.4.2 Limitations of this study

This study also has some limitations. Firstly, during the initial phase of formulating IPTs, all recruited health workers were from the central region of China, which may impact the applicability of the study findings. Therefore, the results of this study should be applied with caution to other contexts with different economic and cultural backgrounds. In addition, the transferability of the findings may also be influenced by the homogeneity of the sample considering gender, age, and education level. The majority of the participants were relatively young, highly educated, and there were few women among them. This may limit the transferability of the results to other smoker groups, such as women, older adults, or individuals with lower levels of education.

Secondly, to understand how smoking cessation apps help smokers in China to quit smoking, important stakeholders include app developers, tobacco control policymakers, health workers who assist smokers in quitting smoking, and app users. Ideally, it would involve all these stakeholders to gain a more comprehensive and deeper understanding of how underlying mechanisms are activated under different contexts to achieve intended outcomes. However, since all smoking cessation apps available on the Chinese market are commercial products and not developed by governmental or research institutions, it is challenging to contact app developers directly because they rarely display their contact information in the app store. Despite this challenge, I still managed to contact an app developer of one smoking cessation app on the market through its website. To confirm his appropriateness for the study as a key stakeholder who could contribute data to formulate IPTs, I had some basic chats with him to identify his logic for designing this app. In preliminary discussions, the app developer mentioned that the app was created based on his personal smoking cessation experiences and that all features and characteristics of the app were designed based on personal ideas rather than being evidence-based. Therefore, I did not interview this app developer. Moreover, in China, including policymakers in research is hardly approachable. Although some smoking cessation studies collaborate with Chinese government bodies, such as the Chinese Center for Disease Control and Prevention (CDC) or prestigious higher

education institutions, this PhD project did not collaborate with such departments, making it difficult to access policymakers or obtain their information. Although I sent emails to the authors of publications in relation to smoking cessation apps in China, who are affiliated with the Chinese CDC, I did not receive replies from them. Therefore, only health workers who assist smokers in quitting smoking and app users were interviewed in this study.

Thirdly, due to time and resource constraints within this PhD project, the formulated IPTs were tested once. As scientific realism suggests, there is no final truth in science (Pawson and Tilley, 1997b). Therefore, the programme theories developed in this study are merely an approximation of reality. Theory testing and refinement is an ongoing process that extends beyond the completion of the study.

Fourthly, since interviews with smokers were conducted online, some important visual cues, such as postures or facial expressions, might be missed (Fielding and Thomas, 2001). In addition, rapport between researchers and participants is essential to guarantee the quality of collected data and improve the understanding of it (Shuy, 2001). Face-to-face interviews are originally favoured by researchers because they make it easier to build and maintain rapport with participants (Shuy, 2001).

Last but not least, the last programme theory of this research found how different usability and user experience attributes link with user engagement levels. As a complementary result of this programme theory, it would be ideal to include a user study to further explore to what extent different usability and user experience attributes affect user engagement levels. However, this idea was not put into practice due to the time and resource limitations of the PhD project.

#### 9.4.3 Practical challenges

The Covid-19 outbreak posed significant challenges to my research. From September 2021 to March 2022, I was busy looking for hospitals willing to allow me to conduct recruitment. At that time, the pandemic prevention policies in China were the strictest, with many hospitals implementing strict policies to prohibit external

visitors. Even inpatients were required to have at most one family member to stay in the hospital, and they were not allowed to leave the hospital during the accompaniment period, or they had to undergo one more set of complicated procedures to be readmitted. As an 'external visitor' who had returned from abroad, it was very difficult for me to even enter hospitals, so I had to contact my academic and social connections for help.

This research is an interdisciplinary study that combines perspectives from HCI and addictive behaviour recovery as well as public health intervention evaluation. When I started this PhD project, all my academic background was public health-related, which encompasses knowledge of medicine and social science. Although I previously had some basic programming skills and successfully developed a prototype app for managing chronic diseases, my expertise in informatics and HCI was limited. To address this gap, I audited HCI-related courses during the first and second years of my PhD. Furthermore, following the advice of my supervision team, I also read books related to user-centered design. In addition, during the data analysis stage, HCI-related codes and themes were discussed with another PhD candidate from the Informatics School at the University of Edinburgh to gain his insights on how to name, map, and categorise these codes and themes.

## 9.5 Implications for future practice

It is important to consider how evidence from this research can inform app developers to design smoking cessation apps that better meet user needs. To inform future practice, the 1<sup>st</sup> qualitative systematic review (Chapter 4) has been published in a peer-reviewed journal (Zhang et al., 2023), and the manuscript of the 2<sup>nd</sup> systematic review (Chapter 5) will be submitted to the International Journal of Medical Informatics after submitting this thesis.

### 9.5.1 Implications for app developers

Since the four programme theories identified in this study are evidence-based, they can be used to develop a smoking cessation app that meets user needs better. When designing a smoking cessation app, it is crucial to have an app feature that displays the positive changes that occur after quitting smoking to boost smokers'

motivation to quit. However, app developers should also consider that different users have varying tolerance levels for negative information. Therefore, when showing negative information, such as the harms of smoking, developers should carefully consider the volume of negative information to avoid causing negative emotions among users. Alternatively, giving users the autonomy to choose the information they need can be beneficial. Incorporating social features in the app can be effective for those who believe social support is essential during the quitting process, but developers should employ strategies to regulate and manage the social platform better to ensure a positive and supportive environment.

Although this study found that user engagement with features that educate withdrawal symptoms management skills was low, this may be due to the lack of personalisation or the low intensity of provided support, for example, remaining at the textual level rather than providing practical guidance, leading users to perceive these functions as having very limited effect. When adding skills education features, app developers should consider personalised information or provide knowledge they did not know before. When offering distraction support, apps should provide not only textual descriptions but also further guidance to increase the intervention's practical content consisting of actionable information and tools. For example, when educating smokers to do some exercise to distract themselves from cravings, additional exercise videos could be added.

Finally, apps should be as intuitive as possible, easy to navigate, incorporate various media formats and give users some autonomy in the interface style to enhance usability. In addition, when designing app features, developers should consider the personalisation of each feature to meet different user preferences and needs, thereby improving the user experience. Although no evidence in this study showed data security concerns, app developers should take adequate measures to ensure data security and clearly inform users about how their data will be used and protected, thereby building user trust in the app.

### 9.5.2 Implications for health workers

Health workers can identify smokers who may benefit most from smoking cessation apps by assessing their levels of motivation and social support. Based on the findings of this study, smokers with high motivation to quit but low social support in their immediate environment are ideal users for these apps, as the social platforms within smoking cessation apps can provide the encouragement and resources they might lack from friends and family. Health workers should advise smokers to try different smoking cessation apps before finding the one that fits their personal preferences and needs most. This tailored approach can help smokers receive the support and tools necessary for a successful cessation journey.

For health workers, they should place greater emphasis in their daily work on educating smokers about the specific harms of smoking and the actual benefits of quitting to enhance their motivation to quit smoking. Furthermore, health workers should educate smokers that having cravings is normal in smoking cessation, so smokers should hold an open and realistic attitude to cravings and relapse. In their daily work, they can identify the main sources of motivation for smokers to quit and provide personalised quitting information and advice tailored to the specific situations of different smokers. For instance, when smokers care more about the health of children, health workers could emphasise the risk of second-hand smoking.

## 9.6 Implications for future research

It is worth exploring whether different stages of behaviour change affect users' needs and expectations about how apps work to help them stop smoking. This would allow app developers to design features targeting different user groups, thereby increasing the accessibility of apps.

Additionally, this study found that smokers with diverse backgrounds have different acceptance levels of social features. Further research could be conducted to explore whether different personal traits of smokers, such as affinity to technology, the existence of in-person support networks, the existence of tangible support, and nicotine dependence level, etc., will affect the engagement level of social features.

The effectiveness of smoking cessation apps can be assessed from multiple dimensions, such as intentions to quit, the ability to resist cravings, self-efficacy, etc., rather than simply counting the smoke-free days (King et al., 2022). This study employs a qualitative method to explore the contextual factors which influence the effects and user engagement level of smoking cessation apps and how the interplay between contexts and mechanisms affects intended and unintended outcomes. Future research could include a quantitative design to examine the extent to which different app features impact various outcomes. Additionally, based on the findings of this research, a new round of theory or hypothesis testing could be considered to refine further the programme theories developed from this study.

Finally, although this study found that good usability and positive user experience can predict user engagement, it was interesting to find that smokers may decrease their engagement levels on apps when they have high self-efficacy. It is worth conducting research to explore the relationship between user engagement levels and smoking cessation outcomes.

## 9.7 Implications for policy

This study found that social support is important in smoking cessation. The Chinese government could consider making funding available to develop or finance community-based support groups that provide a platform for smokers to share their smoking cessation experiences and tips or to encourage each other. Launching public health campaigns that emphasise the role of family, friends, health workers, and smoking cessation peers in pursuing smoking cessation would also be useful.

Despite the international focus on the quality and reliability of health apps, the market is still flooded with low-quality health apps (WHO, 2019a). This indicates that government institutions do not place enough importance on these official guidelines, leading to their low application, or it may be due to the fact that each country has its own unique requirements for developing health apps, including the transparency of design steps, app content, and user privacy and security policy, making the standardised process difficult to achieve (Essén et al., 2022). This study found that good usability and positive user experience of smoking cessation apps are linked

with higher user engagement levels. Government institutions should collaborate with higher education institutions or research organisations to design evidence-based apps that better meet user needs rather than merely developing apps based on personal ideas or the commercial interests of developers. By setting certain development standards, the minimum requirement for developing health-related apps can be raised, enhancing their overall quality and strengthening users' trust and perceived usefulness of these apps.

This study found that the paid membership features will negatively influence user experience and decrease user engagement levels on the premium features. To achieve universal health coverage, one of WHO's recommendations for health-related digital interventions is to ensure accessibility and affordability. In other words, governments should ensure all those in need can access these interventions without causing financial burden. While collaborating with research organisations or higher education institutions to design high-quality smoking cessation apps, Chinese policymakers should also consider linking these apps with national smoking cessation services. This will allow more smokers who want to quit smoking to access these apps through official channels and also enable them to use them for free.

## 9.8 Conclusion

This research aimed to examine what aspects of smoking cessation apps work for Chinese smokers, under what circumstances, and why. In line with this aim, this study employed the realist evaluation approach and identified several contextual factors that lead to the success or failure of smoking cessation apps for Chinese smokers.

This study has provided contributions to the knowledge of using mHealth interventions in addictive behaviour recovery. Four IPTs were formulated through two systematic reviews and interviews with Chinese health workers. Interviews with Chinese smokers were conducted, and data was gathered to test the IPTs. Based on the interview data of smokers, the programme theories were refined and presented using CMOCs to provide guidance to design apps that can meet user needs and promote addictive behaviour recovery with effectiveness, efficiency, and satisfaction.

This study showed motivation plays an important role in breaking the addiction cycle. For smokers who are motivated to stop smoking and believe in the effects of smoking cessation apps, apps could be effective in boosting users' motivations to quit by increasing their knowledge level on the risks of smoking and the benefits of smoking cessation and showing positive changes due to smoking cessation.

Smokers who need social support but fail to get it in real life may appreciate the social features within apps. Apps are advantageous in providing social support to smokers as peers in the social groups share similar barriers and can easily empathise and understand each other, although smokers who engage with the social features may be dissuaded by the poor management and regulations of the social platforms within apps.

Although apps provide features to manage withdrawal symptoms, the user engagement level on the withdrawal symptom education feature was quite low because the support provided in apps lacks practicality and personalisation, failing to offer in-depth support. For smokers who believe they can benefit from recording withdrawal symptoms, this feature has the potential to be effective through acting as a way to vent negative emotions or helping smokers be more aware of their craving patterns. In addition, viewing craving diminishing could also increase smokers' confidence in smoking cessation.

Finally, this study found different attributes of usability and user experience could affect user engagement levels. Governments should employ strategies to design high-quality smoking cessation apps with better usability and user experience design and make them available and affordable to smokers.

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APPENDIX 1: Ethical approval from the University of Edinburgh



**School of Health in Social Science Research Ethics Application**

The supervisor or primary investigator must complete and sign this form after checking that all relevant sections are completed, and relevant documents are attached. For all undergraduate (UG) and MSc student projects, it is the supervisor's responsibility to submit this form and all attachments. **Please note that failure to do this will result in the application being returned (and not processed) causing your research to be delayed.**

Supervisor (name and UUN): Larry Doi	
Primary Investigator (name and UUN): Mengying Zhang, s1887791	
List of all collaborators (with affiliated institutions in brackets):	
Student's programme of study (if applicable): PhD of Nursing	
Project Title: A realist evaluation of the use of smoking cessation apps in China	
Case Number (if known – assigned by Administrator at time of 1 <sup>st</sup> submission):	
Proposed Project Start Date: 15/10/2020	Proposed Project End Date: 30/08/23

**Please indicate whether the primary investigator on this project is staff or student and select your subject area:**

Staff                       UG or MSc Student       DClin Student       PhD Student  
 CPASS                       Clinical Psychology       Nursing Studies

**This is a:**

New application for ethical review – first submission  
 Resubmission following reviewer comments  
 Resubmission with requested amendments

**Has been reviewed by an external ethical board, such as NHS IRAS or a UK HEI (multi-site studies only) with a favourable opinion? Level 1 \***

IRAS (NHS research ethics)     Other: \_\_\_\_\_

**Please tick one option that best describes your application:**

Collecting or generating new data involving other people: Level 2  
 Extracting, re-coding and analysing existing data that contains sensitive information (i.e. identifiable information): Level 2  
 Analysing secondary (archival) data that is routinely collected or is an existing anonymised dataset: Level 1  
 Collecting new data BUT an external ethical review board (such as NHS IRAS; UK HEI – for multi-site studies; etc) has fully reviewed this project and generated a favourable opinion: Level 1

**This application is complete with the following attachments (tick all that apply):**

Advert/flyer <input checked="" type="checkbox"/>	Caldicott application stating what data was requested <input type="checkbox"/>	Caldicott signed approval <input type="checkbox"/>	Consent form/s <input checked="" type="checkbox"/>
Data collection tools (e.g. interview guides) <input checked="" type="checkbox"/>	Debrief with signposting <input checked="" type="checkbox"/>	IRAS application <input type="checkbox"/>	IRAS opinion letter <input type="checkbox"/>
Participant Information Sheet/s <input checked="" type="checkbox"/>	Participant Information Sheet (young person version) <input type="checkbox"/>	R&D application <input type="checkbox"/>	R&D approval <input type="checkbox"/>
			NGO or local authority letters <input type="checkbox"/>
			Researcher Checklist (C-19) <input type="checkbox"/>

\*If your project has been reviewed and generated an opinion by an external agency with a full ethics board, for example IRAS approval from the NHS, you only need to complete the questions related to university regulations covered in the Level 1 section of this form to ensure you are following University policies and guidelines. Please also attach the externally reviewed application and decision letter. Please note that your project will not undergo a full additional ethical review by the School of Health in Social Sciences REC, however we need to ensure your project is adhering to university regulations before you begin collecting data.

Risk assessment <input type="checkbox"/>	Standardised recruitment email <input type="checkbox"/>	Sponsorship Letter OR Email to confirm no sponsorship needed / statement explaining why sponsorship is not needed. <input checked="" type="checkbox"/>
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Other attachments (please specify):

To be completed by primary investigator or project supervisor
<p><b>By signing this front sheet, I confirm that I have prepared and/or reviewed this ethics application and related documents in accordance with ethical guidelines. I also confirm I have checked that all relevant sections of the application form are completed and relevant documents are attached.</b></p> <p><b>Supervisor or/PI Signature: Larry Doi</b></p> <p><b>Student signature: Mengying Zhang</b></p> <p><b>Date: 01/10/21</b></p>

On completion, this Word document along with the relevant attachments should be submitted to [ethics.hiss@ed.ac.uk](mailto:ethics.hiss@ed.ac.uk).

**Note: Please note all undergraduate and MSc applications MUST be signed and submitted by the project supervisor.**

## Contents

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**This section is to be completed after review only**

**ISSUES ARISING FROM THE PROPOSAL – to be completed by Ethics Reviewer**

Thank you for your application. The review process has generated the following queries regarding your application. Please address the following items, and provide a note underneath each comment letting us know how you have addressed them:

OR

Thank you for your application. We have completed the review process and can provide a favourable opinion.

Thank you for your application. The review process has generated the following queries regarding your application. Please address the following items, and provide a note underneath each comment letting us know how you have addressed them in the amendments section of this form:

- Online interviews were stated in the main application, yet audio/video consent form is evident, and this is not explicitly stated in the main application form. The recruitment poster only states: "one to one interview" and the participant information sheet has "in a safe environment" So a bit unclear to participants if this will be at home, the respiratory centre or online. This needs proper clarification please

The first round of interviews with health workers will be conducted in the respiratory department. This will be face-to-face interviews. The second-round interviews with smokers will be conducted in person or online (based on interviewees preferences). Only audio will be recorded using an encrypted recorder. If online interviews are conducted, zoom or phone call will be used. An encrypted recorder will also be used to record the audio. I have clarified the mode of interviews and the interview places in the information sheet. They can choose to be interviewed in a café near to them or at their home. If they choose online interviews, zoom and phone call can be chosen.

- What type of interviews exactly will be conducted- face to face online and in which platforms Zoom or Teams?

The interviews with health workers will be conducted in person in the respiratory department. The second round of interviews with smokers can be in person or online (via zoom or phone call), based on participants' preferences.

- How will this data be stored and managed (will this be downloaded to student's computer or Cloud; how transcriptions and translations be managed to ensure data protection.

An encrypted recorder will be used to record interviews. Audio files of interviews along with interview transcripts and any files containing information about them will be stored securely on the University's OneDrive. This is password protected and only the lead researcher can access them. Once transcription finishes, audio files will be deleted permanently. Transcriptions will be conducted by the lead researcher. The translation process will be conducted by the lead researcher first, and then another PhD student, who has taken part in the data protection training, will do the translation again. Before the other student translate, all identifiable information will be anonymised or removed.

- Will recording consist of both video and audio components?

Only audio will be recorded. I have clarified in the information sheet.

- The duration of the interview is also not stated in none of the documents, and this is important for participants to have the required information-please specify as a guide

I have made this clear in the information sheets for both health workers and smokers. I have also included this information in the poster that all interviews will be around 45-60 minutes, not exceeding 60 minutes

- Consent form – amend to 'I understand that my participation is voluntary and that "I can withdraw at anytime"

Thanks, I have now amended the sentence.

**Signature:** Dr Elaine Haycock-Stuart and Dr Michelle King-Okoye

**Position:** Ethics Lead Nursing Studies

**Date:** 4<sup>th</sup> November, 2021

**APPLICANT'S SIGNATURE FOLLOWING REVISIONS – to be completed by applicant**

I confirm that I have addressed all of the queries generated during the ethical review process of my application. I have outlined in the box above underneath each comment how each request was addressed and/or provided further clarification.

**Supervisor/PI Signature: Larry Doi**

**Student signature: Mengying Zhang**

**Date: 10<sup>th</sup> November, 2021**

**CONCLUSION TO ETHICAL REVIEW – to be completed by Ethics Lead**

The applicant's response to our request for further clarification or changes has now satisfied the requirements for ethical practice and the application has therefore been given a favourable opinion.

**Reviewed by:**

Dr Elaine Haycock-Stuart and Dr Michelle King-Okoye

**Signature:**

**Position: Ethics Lead Nursing Studies**

**Date: 15<sup>th</sup> November 2021**

that a favourable opinion has been provided for this project (for example as an attachment to MSc dissertations).

**NOTE: Once reviewed please include the page on which this box appears as a formal document demonstrating that favourable opinion has been provided for this project (for example as an attachment to MSc dissertations).**

## APPENDIX 2: Information sheet (Health workers)



### **PARTICIPANT INFORMATION SHEET**

#### **A realist evaluation of the use of smoking cessation apps in China**

You are being invited to take part in research on the use of smoking cessation apps. Mengying Zhang, a second year PhD student at the University of Edinburgh is leading this research. Before you decide whether to take part it is important you understand why the research is being conducted and what it will involve. Please take time to read the following information carefully.

#### **WHAT IS THE PURPOSE OF THE STUDY?**

The main aim is to examine, in what way, and under what circumstances, does smoking cessation apps help adult smokers quit smoking in China. The secondary aim is to explore smokers' perspectives, perceptions, and expectations on smoking cessation apps.

#### **WHY HAVE I BEEN INVITED TO TAKE PART?**

You are invited to participate in this study because you have conducted smoking cessation related research before; or you have experience of helping smokers to stop smoking. You do not need to have used smoking cessation apps before.

#### **DO I HAVE TO TAKE PART?**

No – it is entirely up to you. If you do decide to take part, you are still free to withdraw at any time and without giving a reason. Deciding not to take part or withdrawing from the study will not affect any of your employment or your rights.

Please note that your data will be anonymized for data analysis, and it will not be possible to withdraw you data after this point. Please contact the research team at the earliest opportunity if you wish to withdraw from the study.

#### **WHAT WILL HAPPEN IF I DECIDE TO TAKE PART?**

If you do decide to take part, please keep this Information Sheet. You will be asked to complete an online Informed Consent Form to show that you understand your rights in relation to the research, and that you are happy to participate.

You will be invited to an interview with the lead researcher who will ask your demographic information, perspectives on smoking cessation policy context in China and the role mHealth plays to address smoking in China. The interview will take place face-to-face in the respiratory department where you work at a time that is convenient to you. Ideally, we

would like to



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audio record your responses (and will require your consent for this), so the location should be in a quiet area. The interview should take around 45-60 minutes to complete.

#### **WHAT ARE THE POSSIBLE BENEFITS OF TAKING PART?**

There are no direct benefits, but by sharing your experiences with us, you can get a sense of achievement for contributing to the development of mHealth; Your suggestion for the development of smoking cessation apps may be considered in future smoking cessation apps design process.

#### **ARE THERE ANY RISKS OR DISADVANTAGES ASSOCIATED WITH TAKING PART?**

There are no significant risks associated with participation. Taking part will involve 45-60 minutes of your time but the research team will arrange the interview at a time that is most suitable for you.

#### **WILL MY TAKING PART BE KEPT CONFIDENTIAL?**

All the information we collect during the research will be kept confidential and there are strict laws which safeguard your privacy at every stage.

#### **HOW WILL WE USE INFORMATION ABOUT YOU?**

We will need to use the interview data from you for this research project.

People who do not need to know who you are will not be able to see your name or contact details. Your data will have a code number instead.

We will keep all information about you safe and secure.

If you consent to being audio recorded, all recordings will be destroyed once they have been transcribed. Your data will only be viewed by the research team. All electronic data will be stored in the lead researcher's Onedrive, which is safe and only can be accessed by the lead researcher. Your consent information will be kept separately from your responses to minimise risk.

Once we have finished the study, we will not keep the data. We will write our reports in a way that no-one can work out that you took part in the study.

#### **What are your choices about how your information is used?**

- You can stop being part of the study at any time, without giving a reason, but we will keep information about you that we already have.
- We need to manage your records in specific ways for the research to be reliable. This means that we won't be able to change the data we hold about you.

#### **Where can you find out more about how your information is used?**

You can find out more about how we use your information at <https://www.ed.ac.uk/records-management/privacy-notice-research>

- by asking one of the research team
- by sending an email to [s1887791@ed.ac.uk](mailto:s1887791@ed.ac.uk), or
- by contacting the University of Edinburgh Data Protection Officer at [dpo@ed.ac.uk](mailto:dpo@ed.ac.uk)

The University of Edinburgh is the sponsor for this study based in China. We will be using information from you to undertake this study and will act as the data controller for this study. This means that we are responsible for looking after your information and using it properly. The University of Edinburgh will keep identifiable information about you for 1 years after the study has finished and your anonymised data for a minimum of 3 years. Your anonymised data may be used in future ethically approved research.

#### **WHAT WILL HAPPEN WITH THE RESULTS OF THIS STUDY?**

The results of this study may be summarised in published articles, [reports](#) and presentations. You will not be identifiable from any published results. Quotes or key findings will always be made anonymous in any formal outputs unless we have your prior and explicit written permission to attribute them to you by name. A summary of the findings from the study will be made available to participants who indicate they would like to receive this. This summary will be sent to participants by email.

**WHO IS ORGANISING AND FUNDING THE RESEARCH?**

This study has been organised by Mengying Zhang, a PhD candidate in nursing and sponsored by the University of Edinburgh.

This research did not receive any funding.

**WHO HAS REVIEWED THE STUDY?**

The study proposal has been reviewed by School of Health in Social Science Research Ethics Committee at the University of Edinburgh.

**WHO CAN I CONTACT?**

If you have any further questions about the study, please contact the lead researcher, Mengying Zhang, [s1887791@ed.ac.uk](mailto:s1887791@ed.ac.uk)

If you wish to make a complaint about the study, please contact:

Research Governance Team  
[ethics.hiss@ed.ac.uk](mailto:ethics.hiss@ed.ac.uk) .

## APPENDIX 3: Consent form (Health workers)



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### PARTICIPANT CONSENT FORM

Project title: A realist evaluation of smoking cessation apps in China

Researcher's name and contact details:

Mengying Zhang

[s1887791@ed.ac.uk](mailto:s1887791@ed.ac.uk)

+86 18163511121



1. I confirm that I have read and understood the Participant Information Sheet (Version 1, 13/10/21) for the above study
2. I have been given the opportunity to consider the information provided, ask questions and have had these questions answered to my satisfaction
3. I understand that my participation is voluntary and that I can ask to withdraw at any time.
4. I understand that my anonymised data will be stored for a minimum of 3 years and may be used in future published papers, reports, and ethically approved research.
5. I understand that relevant data collected during the study may be looked at by individuals from the Sponsor (University of Edinburgh), where it is relevant to my taking part in this research. I give permission for these individuals to have access to my data.
6. I agree to my interview being audio recorded
7. I agree to take part in the above study

Name of person giving consent

Date

Signature



Name of person taking consent

Date

Signature

## APPENDIX 4: Interview guide (Health workers)



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### A realist evaluation of smoking cessation apps in China

#### Introduction

Thank you for agreeing to take part in this research. We are interested in your opinions about smoking cessation policy context in China and how mHealth can help people stop smoking.

We expect the interview to last between 45 and 60 minutes, but we can stop to take a break at any point, and you can finish the interview at any time without giving an explanation.

[If participant has consented to be recorded, switch on the recorder]

May I double-check that you are happy for this interview to be recorded?

[Continue recording if participant has confirmed their consent.]



	<b>Question</b>	<b>Logic</b>
1	Would you mind telling me your age and your profession?	Question1-2 are Demographic information
2	How long have you worked as a doctor/nurse?	
3	What pros and cons of using Mhealth to help people change their behaviours? Such as Keep or Mint or any other app that can help people live healthier. And could you explain why you think it is convenient/ healthy...	Questions 3-5 are introductory questions to get them talking.
4	Could you explain in what circumstances will you recommend patients to stop smoking?	
5	What kinds of smoking cessation methods you know or exist in the hospital/clinic? Could you tell me some difficulties when you use these methods to help people stop smoking?	
6	Could you tell me what kinds of needs patients have when they quit smoking? (Physically and psychologically)	Question 6-7 are about users' needs
7	Do you think smoking cessation apps can meet their	

needs when stop smoking? And could you explain what roles smoking cessation apps play?

- 8 In your opinion, What kinds of external stimulus, (such as 1. supports from their families or friends, 2. stay in a competing environment, 3. Money incentives, 4. Health education.....) can help them stop smoking? Question 8-9 are about motivations to stop smoking
- 9 What kinds of psychological impacts can be caused by those external stimuli? And could you explain why?
- 10 If there is a smoking cessation app, would you recommend it to your patients? If yes, could you explain what aspects of smoking cessation apps are likely to be useful to your patients (personalized, attach to guidelines, interactive, safe.....). If no, could you give me some reasons? Question 10 is about usability and user experience of smoking cessation apps
- 11 If there is a smoking cessation app, what app functions do you think would be important? And could you explain why you think they are vital? Question 11 is about app functions
- 12 Could you tell me what are the reasons why patients decide to stop smoking? Question 12-13 are about facilitators and barriers of smoking cessation among Chinese smokers
- 13 What factors will impede them keeping quitting smoking during smoking cessation?
- 14 Could you explain, as a health worker, how can you help them overcome the difficulties? What kinds of techniques do you use when helping them quit smoking? Question 14 is about health workers' opinions on mHealth interventions to assist smoking cessation
- 15 What changes will happen to patients after they use smoking cessation apps to stop smoking? (more caring about their health, become more confident) Question 15 is about outcomes after using smoking cessation apps
- 16 Do you think smoking cessation apps could help to reduce the smoking rate in China? And why? Question 16 is the end question to explore health workers' confidence on mHealth interventions and their expectations

## APPENDIX 5: Information sheet (Smokers)



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### **PARTICIPANT INFORMATION SHEET**

#### **A realist evaluation of the use of smoking cessation apps in China**

You are being invited to take part in research on the use of smoking cessation apps. Mengying Zhang, a second-year PhD student at the University of Edinburgh, is leading this research. Before you decide whether to take part it is important you understand why the research is being conducted and what it will involve. Please take time to read the following information carefully.

#### **WHAT IS THE PURPOSE OF THE STUDY?**

The main aim is to examine, in what way, and under what circumstances, does smoking cessation apps help adult smokers quit smoking in China. The secondary aim is to explore smokers' perspectives, perceptions, and expectations on smoking cessation apps.

#### **WHY HAVE I BEEN INVITED TO TAKE PART?**

You are invited to participate in this study because you are 1) over 18 years old, 2) smoker or ex-smoker, 3) have used smoking cessation apps before

#### **DO I HAVE TO TAKE PART?**

No – it is entirely up to you. If you do decide to take part, you are still free to withdraw at any time and without giving a reason. Deciding not to take part or withdrawing from the study will not affect any of your rights or healthcare you receive.

Please note that your data will be anonymized for data analysis, and it will not be possible to withdraw your data after this point. Please contact the research team at the earliest opportunity if you wish to withdraw from the study.

#### **WHAT WILL HAPPEN IF I DECIDE TO TAKE PART?**

If you do decide to take part, please keep this Information Sheet. You will be asked to complete an online Informed Consent Form to show that you understand your rights in relation to the research, and that you are happy to participate.

You will be invited to an interview with the lead researcher who will ask your demographic information and your opinions regarding your expectations and perceptions on smoking cessation apps. The interview can take place at a café near to you or at your home at a time that is convenient to you. Ideally, we would like to audio record your responses (and



will require your consent for this), so the location should be in a quiet area. The interview should take around 45-60 minutes to complete. If it is impossible to conduct interviews in person, online interviews (using zoom or phone call) can be arranged for you.

**WHAT ARE THE POSSIBLE BENEFITS OF TAKING PART?**

There are no direct benefits, but by sharing your experiences with us, you can get a sense of achievement for contributing to the development of mHhealth; Your suggestion for the development of smoking cessation apps may be considered in priority during the design process.

**ARE THERE ANY RISKS OR DISADVANTAGES ASSOCIATED WITH TAKING PART?**

There are no significant risks associated with participation. Taking part will involve 45-60 minutes of your time but the research team will arrange the interview at a time that is most suitable for you. Due to the pandemic is uncertain, online interviews may be conducted.

**WILL MY TAKING PART BE KEPT CONFIDENTIAL?**

All the information we collect during the research will be kept confidential and there are strict laws which safeguard your privacy at every stage.

**HOW WILL WE USE INFORMATION ABOUT YOU?**

We will need to use the interview data from you for this research project.

Collected data will include your name, expectations, and perceptions of smoking cessation apps. People will use the data to do this research.

People who do not need to know who you are will not be able to see your name or contact details. Your data will have a code number instead.

We will keep all information about you safe and secure.

If you consent to being audio recorded, all recordings will be destroyed once they have been transcribed. Your data will only be viewed by the research team. All electronic data will be stored on a secure password-protected device. Your consent



information will be kept separately from your responses to minimise risk.

Once we have finished the study, we will keep some of the data so we can check the results. We will write our reports in a way that no-one can work out that you took part in the study.

### **What are your choices about how your information is used?**

- You can stop being part of the study at any time, without giving a reason, but we will keep information about you that we already have.
- We need to manage your records in specific ways for the research to be reliable. This means that we won't be able to let you see or change the data we hold about you.

### **Where can you find out more about how your information is used?**

You can find out more about how we use your information at <https://www.ed.ac.uk/records-management/privacy-notice-research>

- by asking one of the research team
- by sending an email to [s1887791@ed.ac.uk](mailto:s1887791@ed.ac.uk), or
- by contacting the University of Edinburgh Data Protection Officer at [dpo@ed.ac.uk](mailto:dpo@ed.ac.uk)

The University of Edinburgh is the sponsor for this study based in China. We will be using information from you to undertake this study and will act as the data controller for this study. This means that we are responsible for looking after your information and using it properly. The University of Edinburgh will keep identifiable information about you for 1 year after the research finish and your anonymised data for a minimum of 3 years. Your anonymised data may be used in future ethically approved research

### **WHAT WILL HAPPEN WITH THE RESULTS OF THIS STUDY?**

The results of this study may be summarised in published articles, reports, and presentations. You will not be identifiable from any published results. Quotes or



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key findings will always be made anonymous in any formal outputs unless we have your prior and explicit written permission to attribute them to you by name.

With your consent, your anonymised information may also be kept for future research. A summary of the findings from the study will be made available to participants who indicate they would like to receive this. This summary will be sent to participants by email.

#### **WHO IS ORGANISING AND FUNDING THE RESEARCH?**

This study has been organised by Mengying Zhang, a PhD candidate in nursing and sponsored by the University of Edinburgh.  
This research did not receive any funding.

#### **WHO HAS REVIEWED THE STUDY?**

The study proposal has been reviewed by School of Health in Social Science Ethics Committee at the University of Edinburgh.

#### **WHO CAN I CONTACT?**

If you have any further questions about the study, please contact the lead researcher, Mengying Zhang, [s1887791@ed.ac.uk](mailto:s1887791@ed.ac.uk)

If you wish to make a complaint about the study, please contact:

Research Governance Team  
[cahss.res.ethics@ed.ac.uk](mailto:cahss.res.ethics@ed.ac.uk)

## APPENDIX 6: Consent form (Smokers)



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of EDINBURGH

### **PARTICIPANT CONSENT FORM**

#### **Project title: A realist evaluation on smoking cessation apps in China**

Researcher's name and contact details:

Mengying Zhang

[s1887791@ed.ac.uk](mailto:s1887791@ed.ac.uk)

+86 18163511121

1. I confirm that I have read and understood the Participant Information Sheet (Version 1, 13/10/21) for the above study
2. I have been given the opportunity to consider the information provided, ask questions and have had these questions answered to my satisfaction
3. I understand that my participation is voluntary and that I can ask to withdraw at any time.
4. I understand that my anonymised data will be stored for a minimum of 3 years and may be used in future published papers, reports, or ethically approved research.
5. I understand that relevant data collected during the study may be looked at by individuals from the Sponsor (University of Edinburgh), where it is relevant to my taking part in this research. I give permission for these individuals to have access to my data.
6. I agree to my interview being audio recorded
7. I agree to take part in the above study

Name of person giving consent      Date      Signature

Name of person taking consent      Date      Signature

## APPENDIX 7: Interview guide (Smokers)



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### A realist evaluation of smoking cessation apps in China

#### Introduction

Thank you for agreeing to take part in this research. We are interested in your opinions about how mHealth can help people stop smoking and your expectations on smoking cessation apps.

We expect the interview to last between 45 and 60 minutes, but we can stop to take a break at any point, and you can finish the interview at any time without giving an explanation.

[If participant has consented to be recorded, switch on the recorder]

May I double-check that you are happy for this interview to be recorded?

[Continue recording if participant has confirmed their consent.]



No.	Question	Logic
1	Could you tell me your age and where you come from?	Q1-Q4 are introductory questions to get people talking
2	Could you tell me when you started smoking and why you started it? How many times have you tried to stop smoking? How many cigarettes did you smoke every day before? In what circumstances you were likely to smoke?	
3	Which smoking cessation app are you using? Could you tell me how long you have used the smoking cessation app?	
4	Could you tell me about the overall impression on this app?	
6	Could you tell me what personal facilitators or barriers exist during smoking cessation? Such as lack motivation, social support, having withdrawal symptoms etc. (ask participants to expand)	Explore overall facilitators and barriers in smoking cessation, to explore the potential effects of apps
7	Could you tell me how the smoking cessation app can help you overcome the barriers you mentioned?	Explore overall effects of smoking cessation apps
8	Is it easy for you to stop smoking in China, especially in your living environment, why? What supports do you need during smoking cessation? (Family, friends, peers...)	Link with Chinese tobacco culture to explore the contexts of social support features of apps
9	Does the smoking cessation app change the situation you faced? And how does it achieve that?	Explore the potential mechanisms and outcomes of social support features
10	Why did you start smoking at the beginning? Why did	Explore motivations for

	you give up this pleasures/convenience that smoking brought to you and choose to stop smoking?	smoking cessation and the potential effects of apps to maintain these motivations
11	What the smoking cessation app can give to you to replace the pleasure / intrinsic / extrinsic rewards you get from smoking? (Prompts: benefits of smoking cessation, risks of smoking etc.)	Mechanisms and Outcomes in maintaining/boosting motivations
12	Could you tell me about your thoughts on the risk of smoking or benefits of stop smoking?	Explore smokers' knowledge level on smoking and smoking cessation
13	How can the smoking cessation app help you to change your attitudes toward smoking behaviour?	Explore the effects of smoking cessation apps to help smokers boost intrinsic motivations to stop smoking
14	Do you think you can succeed in smoking cessation? Why? Did your confidence on successfully stop smoking change since you used the smoking cessation app?	Explore apps' effects on boosting self-efficacy
15	Could you tell me your withdrawal symptoms, including having cravings? And how did you deal with these symptoms?	Explore the relapse triggers and smokers' personal strategies
16	What support did the smoking cessation app provide to overcome these withdrawal symptoms? (Prompts: recording cravings, education...)	Explore the potential effects of smoking cessation apps to help smokers prevent relapse
17	Which aspects made you satisfied or dissatisfied with this app? (Prompts: ease of use, personalisation, aesthetics, advertisement etc.) Ask participants to expand. How these aspects influence your willingness to use this app? And why?	Explore the usability and user experience of smoking cessation apps, and the impacts on use engagement level
18	What are your suggestions for the smoking cessation app? And can you tell me why you want to add this function/characteristic?	Explore further app functions or characteristics

## APPENDIX 8: Screenshots of health worker interviews code (Exported from NVivo)

Name	Description	Files	References
Barriers to smoking cessation in China	Challenges faced by Chinese smokers who attempt to quit smoking in the context of China	6	62
Chinese smoking culture		6	22
lack of knowledge		4	7
lack of motivation		6	18
negative emotions		6	15
Perceived benefits of mHealth interventions	What benefits Chinese smokers can get from using smoking cessation apps, based on health workers' views.	4	26
positive psychological hints		4	12
social support		4	14
Worries about smoking cessation apps	Health workers' views on using mHealth interventions in aiding smoking cessation and their opinions on which aspects of these intervention could be improved to guarantee effectiveness.	6	14

## APPENDIX 9: Screenshots of smoker interview code (Exported from NVivo)

Name	Description	Files	References
Disengagement with social functions	Reasons why smokers disengage with social features	7	10
Education on withdrawal symptoms	Education on tips to prevent relapse	6	12
Motivations for smoking cessation	The driving force that pushes smokers to change their smoking behaviour and the strengthening of their desire to do so	23	230
Extrinsic motivation		12	25
Intrinsic motivation		20	54
Transformation from extrinsic motivation to intrinsic motivation		23	114
Perceived usefulness	The extent to which smokers believe smoking cessation apps are effective	21	38
Self-efficacy	Individual's belief in his own ability to achieve specific goals and it reflects his confidence to take control over his behaviours	22	45
Social isolation	Smokers having minimal social connections with others, leading to feelings of loneliness, which can negatively affect smokers' psychological or mental health	17	35
Lack of support in real life		1	1
Social stigma		10	15
Social support	Social support features in apps that provide a platform for smokers to receive support, empathy and encouragement and share smoking cessation experiences	22	100
Emotional support		13	23
Encouragement		11	14
Informational support		10	24
sense of healthy competition		2	4
Usability	How smoking cessation apps help smokers stop smoking effectively, efficiently, with user satisfaction	12	58
ease of use		5	10
multiple modalities		6	34
visual design		7	14
User experience	Users' responses or perceptions arising from the use of smoking cessation apps	22	58

advertising and membership fee		1	5
gamification		3	3
personalisation		13	19
record keeping		14	15
user privacy		13	16
Withdrawal symptoms recording	Documentation of withdrawal symptoms to prevent relapse	7	15

## APPENDIX 10: Sponsorship letter from the University of Edinburgh



University of Edinburgh  
College of Arts, Humanities and Social Sciences  
Research Governance Office  
55 George Square  
Edinburgh  
EH8 9JU

29<sup>th</sup> October 2021

Mengying Zhan  
c/o Health in Social Science  
University of Edinburgh

Dear Mengying

**Study Title:** A realist evaluation of the use of smoking cessation apps in China

**Sponsor number:** CAHSS2110/02

Under the requirements of the UK policy framework for health and social care research, the University of Edinburgh agrees in principle to act as Sponsor for this project. Sponsorship is subject to you obtaining institutional ethics for the project.

As Chief Investigator, you must ensure that the study does not commence until all applicable approvals have been obtained. Following receipt of all relevant approvals, you should ensure that any amendments to the project are notified to the Sponsor.

Yours sincerely

Charlotte Smith

Research Governance Manager



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## Review article

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

Mengying Zhang<sup>a,d,\*</sup>, Maria Wolters<sup>b</sup>, Siobhán O'Connor<sup>c</sup>, Yajing Wang<sup>a</sup>, Lawrence Doi<sup>a,d</sup><sup>a</sup> School of Health in Social Science, The University of Edinburgh, UK<sup>b</sup> School of Informatics, The University of Edinburgh, UK<sup>c</sup> School of Health Sciences, The University of Manchester, UK<sup>d</sup> Scottish Collaboration for Public Health Research & Policy, The University of Edinburgh, UK

## 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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<https://doi.org/10.1016/j.ijmedinf.2023.105069>

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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	1. (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. 2. (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 ipad OR iphone OR android OR iOS OR blackberry OR "telemedicine").mp. 3. (perspect* OR belief* OR attitude* OR view* OR opinion* OR experien* OR behavio* OR expect* OR knowledge).mp.
MEDLINE	1. ("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 2. ("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 3. (perspect* OR belief* OR attitude* OR view* OR opinion* OR experien* OR behavio* OR expect* OR knowledge).mp.
PsycINFO	1. ("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 2. ("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 3. perspect* OR belief* OR attitude* OR view* OR opinion* OR experien* OR behavio* OR expect* OR knowledge
EMBASE	1. ("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 2. ("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 3. perspect* OR belief* OR attitude* OR view* OR opinion* OR experien* OR behavio* OR expect* OR knowledge
ACM digital library	1. smok* OR vape* OR e-cigarettes 2. stop* OR quit* OR cessation OR behave*
IEEE Xplore	(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)

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 socioeconomic 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

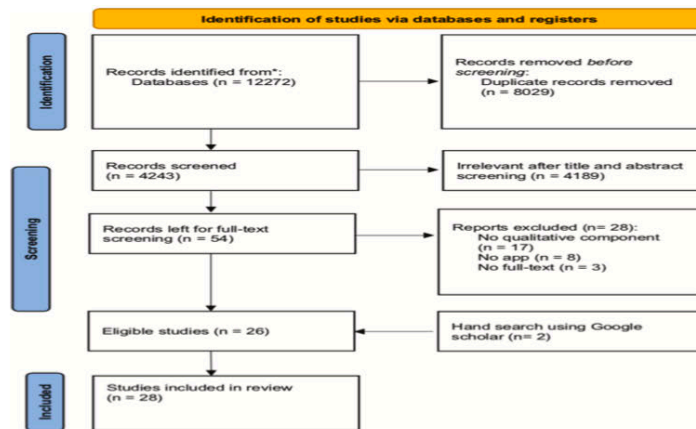


Fig. 1. PRISMA flowchart of the screening process.

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	Amin et al. [2]/ USA	<b>Aim:</b> To gain users' opinions to refine app content. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative descriptive design. <b>Data collection:</b> Focus group, Questionnaire, User testing. <b>Data analysis:</b> 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	<b>Users wanted the app:</b> 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. <b>Users liked the app:</b> 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. <b>Users wanted the app to cover:</b> 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.
2	Baskerville et al. [4]/ Canada	<b>Aim:</b> To describe the process of developing Crush the Crave (CTC) and to evaluate the effectiveness of this app. <b>Setting:</b> Not reported.	<b>Design:</b> Five iterative cycles: listen, plan, do, act, and study using a STAR model. <b>Data collection:</b> Focus group. <b>Data analysis:</b> 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	<b>Users wanted the app to cover:</b> 1. Personalisation; 2. 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. <b>Users liked the app:</b> 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	<b>Aim:</b> 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. <b>Setting:</b> Not reported.	<b>Design:</b> Mixed methods approach by collecting (1) qualitative data via a targeted search strategy to identify user reviews; (2) quantitative data via MAiNS and user star ratings to determine mean objective and subjective ratings of app quality. <b>Data collection:</b> 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) <b>Data analysis:</b> Thematic analysis	N/A	Forty-eight versions of 42 apps met eligibility criteria.  Sources: N/A	NO (Apps in Google Play and Apple Store)	<b>Users wanted the app:</b> 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	<b>Aim:</b> To investigate how the gamification of mHealth interventions leads to a change in health behaviours, especially smoking behaviour. <b>Setting:</b> Not reported.	<b>Design:</b> A qualitative longitudinal study. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 6-phase analytic framework.	Adult smokers (N = 16), 11 males, 5 females.	Puff away / Kwit 2  Sources: N/A	NO (Downloaded from App Stores)	<b>Users wanted the app to be:</b> 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	<b>Aim:</b> To present a series of steps undertaken during the development of Cigbreak, a gamified smoking cessation app. <b>Setting:</b> University.	<b>Design:</b> 7-stage design. <b>Data collection:</b> Focus group. <b>Data analysis:</b> 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	<b>Users wanted the app to cover:</b> 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	<b>Aim:</b> To translate behaviour change technique concepts into digital content within the app. <b>Setting:</b> Not reported.	<b>Design:</b> Participatory design focusing on person-centred approaches. <b>Data collection:</b> "Think aloud" session. <b>Data analysis:</b> 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	<b>Users liked the app:</b> 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. <b>Users disliked the app:</b> 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. <b>Users wanted the app to cover:</b> 1. Had a trustworthy logo, such as NHS; 2. Added a booking function sent an automatic appointment to the user's outlook or other phone calendar.
7	Gowarty et al. [15]/ USA	<b>Aim:</b> To explore attitudes toward smoking cessation apps and preferences regarding app design in young adult smokers with serious mental illness. <b>Setting:</b> A community mental health care.	<b>Design:</b> An exploratory qualitative study <b>Data collection:</b> Focus groups <b>Data analysis:</b> Thematic analysis	Adult smokers with serious mental illness (N = 22), 10 females.	N/A	N/A	<b>Users wanted the app:</b> 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	<b>Aim:</b> To determine the user experience, usability, and acceptability of QuitGuide and quitSTART—among young adult tobacco users with severe mental diseases. <b>Setting:</b> A community mental health	<b>Design:</b> Mixed method approach <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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	<b>Users liked the app:</b> 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.					<b>Users disliked the app:</b> 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.  <b>Users wanted the app to cover:</b> 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.
9	Herbst et al. [18]/ USA	<b>Aim:</b> To examine the acceptability, user experience, and perceptions of the app. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative evaluation design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> Thematic analysis.	Smokers who were military veterans with posttraumatic stress disorder (PTSD) (N = 17), 17 males.	Stay Quit Coach  Sources: The National Centre for PTSD designed the app based on behavioural and pharmacotherapy treatment	YES	<b>Users liked the app:</b> 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. <b>Users disliked the app:</b> 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. <b>Users wanted the app to cover:</b> 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  (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)
10	Klein et al. [21]/ Australia	<b>Aim:</b> To explore the feasibility, acceptability, and utility of <i>Kick.it</i> to assist smokers with severe mental diseases to prevent smoking relapse and quit. <b>Setting:</b> Not reported.	<b>Design:</b> Co-design methodology. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> Thematic analysis.	Adult smokers/ex-smokers with mental diseases (N = 12), 8 males, 4 females.	<i>Kick.it</i>  Sources: An analysis of literature combined with stakeholder input from health professionals and smokers, using intervention mapping development framework	YES	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.  <b>Users liked the app:</b> 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.  <b>Users disliked the app:</b> Difficult to navigate the app because of limited knowledge and skills in technology.  <b>Users wanted the app to cover:</b> 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	Lana-Perejon et al. [24]/ Spain	<b>Aim:</b> To evaluate the user experience, and more specifically the usability and the user satisfaction with the app. <b>Setting:</b> University.	<b>Design:</b> Cohort study. <b>Data collection:</b> Questionnaire and expert report. <b>Data analysis:</b> 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	<b>Users disliked the app:</b> 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. <b>Users liked the app:</b> It was easy to use. <b>Users wanted the app to cover:</b> 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.
12	Maramis et al. [25]/ Finland	<b>Aim:</b> To present the development of QuitIT! As well as its preliminary evaluation. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative evaluation design. <b>Data collection:</b> Interviews. <b>Data analysis:</b> 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	(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)
13	Meijer et al. [28]/ Netherlands	<b>Aim:</b> To evaluate StopCoach and to explore the experience of smokers using StopCoach. <b>Setting:</b> Blended care settings within five municipalities in The Netherlands.	<b>Design:</b> Mixed-methods design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> Framework Analysis.	Lower socio-economic status (SES) smokers (n = 22); Sex ratio was not reported.	StopCoach  Sources	YES	<b>Users liked the app:</b> 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. <b>Users wanted the app to cover:</b> 1. Locations of their smoking reports 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.
14	Naughton et al. [30]/ UK	<b>Aim:</b> 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. <b>Setting:</b> Not reported.	<b>Design:</b> An explanatory sequential, mixed-methods design. <b>Data collection:</b> Interviews. <b>Data analysis:</b> 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	<b>Users liked the app:</b> 1. Locations of their smoking reports 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. <b>Users wanted the app to cover:</b> 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. <b>Users disliked the app:</b> 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.
15	Paay et al. [31]/ Denmark	<b>Aim:</b> To explore how participants, smokers and ex-smokers, interacted with the different content types and sources of Quitty. <b>Setting:</b> University.	<b>Design:</b> Qualitative exploratory design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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 behavior change using technology and incorporated findings from literature to design the app	YES	<b>Users liked the app:</b> 1. Was easy to use; 2. Users were interested in the
16	Paay et al. [32]/ Denmark	<b>Aim:</b> To discuss participants' experience with the app and the role	<b>Design:</b> Qualitative descriptive design.	Adult smokers or recently quit but want	QuittyLink	YES	(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)
		it played in their smoking cessation. <b>Setting:</b> Not reported.	<b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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. <b>Users wanted the app:</b> 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.
17	Paay et al. [33]/ Denmark	<b>Aim:</b> To gain smokers' and ex-smokers' attitudes towards quitting, and their ideas about how interactive technology might be used to help them quit. <b>Setting:</b> Not reported.	<b>Design:</b> An empirical investigation. <b>Data collection:</b> Focus group and design workshops. <b>Data analysis:</b> 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)	<b>Users wanted the app:</b> 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	<b>Aim:</b> To explore how smokers responded to entering data about their smoking habits and then receive personal counselling advice. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative evaluation design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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	<b>Users liked the app:</b> 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. <b>Users wanted the app:</b> 1. They can choose the timeframe of the graphs (continued on next page)

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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	<b>Aim:</b> To assess the feasibility and acceptability and explore the effectiveness of a novel mHealth app to assist Aboriginal people to quit smoking. <b>Setting:</b> Community.	<b>Design:</b> A pilot randomised controlled trial (RCT) plus process evaluation. <b>Data collection:</b> A questionnaire and semi-structured interviews. <b>Data analysis (interview only):</b> 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	<b>Users liked the app:</b> 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. <b>Users wanted the app:</b> 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	<b>Aim:</b> To explore the views of postpartum women on the two components of the Stay Quit Together postpartum smoking relapse prevention intervention – the iCoach mobile application and the text messages. <b>Setting:</b> Obstetrics and gynaecology clinic.	<b>Design:</b> Qualitative exploratory design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> Thematic analysis.	Women who just gave birth, have tried quitting before or during pregnancy (N = 12).	iCoach Sources: N/A	YES	<b>Users liked the app:</b> The panic advice and daily advice were useful. <b>Users disliked the app:</b> 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	<b>Aim:</b> To examine what influenced people to engage or disengage with the app, and how the app was deployed in quit attempts. <b>Setting:</b> Not reported.	<b>Design:</b> A qualitative exploratory design. <b>Data collection:</b> interviews. <b>Data analysis:</b> 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	<b>Users liked the app:</b> 1. Had authentic and contextualised stories; 2. Stories had specific advice that was contextualised. <b>Users wanted the app:</b> 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	<b>Aim:</b> 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. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative case study. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> Framework approach.	Young adult smokers (N = 31), 13 females and 18 males.	Crush the Grave 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	<b>Users liked the app:</b> 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. (continued on next page)

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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)
23	Struik et al. [44] / Canada	<b>Aim:</b> 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. <b>Setting:</b> Not reported.	<b>Design:</b> Qualitative case study design. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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	<b>Users disliked the app:</b> 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. <b>Users liked the app:</b> 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. <b>Users disliked the app:</b> 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. <b>Users liked the app:</b> 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. <b>Users disliked the app:</b> 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. <b>Users liked the app:</b> 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 (continued on next page)
24	Schick et al. [40] / UK	<b>Aim:</b> To evaluate the app as a potential smoking cessation aid and explore user experience and technological requirements and security of the data flow. <b>Setting:</b> NHS Fife GP practice.	<b>Design:</b> Pre- and post-quit two-phase design. <b>Data collection:</b> Two face-to-face interviews, and one telephone interview. <b>Data analysis:</b> Not reported.	Adult smokers who are interested in smoking cessation (N = 8), gender was not reported.	MapMysmoke  Sources: N/A	YES	<b>Users liked the app:</b> 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. <b>Users disliked the app:</b> 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. <b>Users liked the app:</b> 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 (continued on next page)
25	Tudor-Sfetea et al. [48] / UK	<b>Aim:</b> 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. <b>Setting:</b> not reported.	<b>Design:</b> A qualitative short-term longitudinal study. <b>Data collection:</b> Semi-structured interviews. <b>Data analysis:</b> 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)	<b>Users disliked the app:</b> 1. The 'context behaviour therapy' method contributed to their intrinsic motivation to quit. <b>Users disliked the app:</b> 1. The 'lapse' function; 2. Lacking interactivity caused boredom and a decreased desire to use the app; 3. Lacking human contact from a physician. <b>Users liked the app:</b> 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. <b>Users wanted the app:</b> 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. <b>Users disliked the app:</b> 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. <b>Users wanted the app:</b> 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. <b>Users liked the app:</b> 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. (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)
26	Vilardaga et al. [49] / USA	<b>Aim:</b> To evaluate user experience of the app amongst people with serious mental illness. <b>Setting:</b> A community mental health clinic.	<b>Design:</b> Qualitative evaluation design. <b>Data collection:</b> Questionnaire, Semi-structured interviews, Think aloud procedure, Daily diary. <b>Data analysis:</b> Affinity diagram, a grounded field theory approach.	Adult smokers who take psychiatric medication as prescribed (N = 5), 5 males.	Quitpal  Sources: The app design was based on US Clinical Practice Guidelines for smoking cessation	YES	<b>Users disliked the app:</b> 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. <b>Users wanted the app:</b> 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. <b>Users liked the app:</b> 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. (continued on next page)
27	Vilardaga et al. [50] / USA	<b>Aim:</b> 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	<b>Design:</b> Case studies. <b>Data collection:</b> System usability scale, UX interviews and background analytics. <b>Data analysis:</b> Thematic analysis.	Adult smokers with serious mental health diseases, who have an intention to quit (N = 7), 4 females and 3 males.	Learn to Quit/ QuitGuide  Sources: LTQ was designed based on Acceptance and Commitment Therapy.	YES	<b>Users disliked the app:</b> 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. <b>Users wanted the app:</b> 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. <b>Users liked the app:</b> 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. (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)
		were similar or different. <b>Setting:</b> Mental health clinic.			QG was designed based on US Clinical Practice Guidelines for smoking cessation		<b>Users disliked the app:</b> 1. QuitGuide was not intuitive and was difficult to access app functions; 2. QuitGuide had a 'serious' look and feel. <b>Users wanted the app:</b> 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.
28	Wu et al. [56]/ UK	<b>Aim:</b> 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. <b>Setting:</b> Stop-smoking clinics and pregnancy-specific forums.	<b>Design:</b> Qualitative exploratory design. <b>Data collection:</b> Interviews. <b>Data analysis:</b> 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	<b>Users wanted the app:</b> 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.  <b>Users liked the app:</b> 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-Sfetcu et al. [48]	✓	✓	✓		✓	✓		✓		✓	
26. Vilardaga et al. [49]		✓		✓		✓				✓	
27. Vilardaga et al. [50]		✓			✓	✓				✓	
28. Wu et al. [56]	✓		✓					✓			
<b>Total</b>	<b>14</b>	<b>21</b>	<b>19</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>18</b>	<b>17</b>	<b>7</b>	<b>14</b>	<b>4</b>

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**Table 5a**  
Illustrative quotes (examples) from included studies to support the App Functions theme.

<p><b>Subtheme 1: Education</b></p> <p>"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]</p> <p>"Maybe it could give you an explanation of how your health is improving." [10]</p> <p><b>Subtheme 2: Tracking</b></p> <p>"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]</p> <p>"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]</p> <p>"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]</p> <p>"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]</p> <p><b>Subtheme 3: Social support</b></p> <p>"Don't want to share progress on social media in case you fail." [48]</p> <p>"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]</p> <p>"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]</p> <p>"You'd have each other to lean on and to express what you're feeling" [35]</p> <p>"It's like relating your experiences to theirs and trying to find what you can do about it" [42]</p> <p>"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]</p> <p><b>Subtheme 4: Compensation</b></p> <p>"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]</p> <p>"My reward should be bigger than how delicious I think it is to smoke." [33]</p> <p>"Cigarettes are rewarding to us, physically and psychologically, they're rewarding.... Give me the reward, man! ...I quit [smoking]" [2]</p> <p>"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]</p> <p>"After a week if would be good to tot up how much money you have saved." [10]</p> <p><b>Subtheme 5: Distraction</b></p> <p>"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]</p> <p>"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]</p> <p>"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]</p> <p>"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]</p> <p><b>Subtheme 6: Reminding</b></p> <p>"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]</p> <p>"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]</p> <p>"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]</p> <p>"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]</p> <p>"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]</p>	<p><b>Table 5b</b> Illustrative quotes (examples) from included studies to explain the theme App Characteristics.</p> <p><b>Subtheme 1: Simplification</b></p> <p>"Easy and fast. It takes a quarter of a second to open and then you just press save and 'bang', you are done" [34]</p> <p>"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]</p> <p><b>Subtheme 2: Personalisation</b></p> <p>"It means a lot that it was written specifically to me, what I should do, and not what others should do" [34]</p> <p>"Being personalized is definitely important." [10]</p> <p><b>Subtheme 3: Diverse content formats</b></p> <p>"There is too much text. There should be more images" [38]</p> <p><b>Subtheme 4: Interactivity</b></p> <p>"It just needs to be made more interactive." [48]</p> <p>"It has to be interactive to work." [10]</p> <p>"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]</p> <p><b>Subtheme 5: Privacy and Security</b></p> <p>"The safety of the program - the personal data, so nobody can access it" [38]</p>
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**Table 5b**  
Illustrative quotes (examples) from included studies to explain the theme App Characteristics.

<p><b>Subtheme 1: Simplification</b></p> <p>"Easy and fast. It takes a quarter of a second to open and then you just press save and 'bang', you are done" [34]</p> <p>"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]</p> <p><b>Subtheme 2: Personalisation</b></p> <p>"It means a lot that it was written specifically to me, what I should do, and not what others should do" [34]</p> <p>"Being personalized is definitely important." [10]</p> <p><b>Subtheme 3: Diverse content formats</b></p> <p>"There is too much text. There should be more images" [38]</p> <p><b>Subtheme 4: Interactivity</b></p> <p>"It just needs to be made more interactive." [48]</p> <p>"It has to be interactive to work." [10]</p> <p>"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]</p> <p><b>Subtheme 5: Privacy and Security</b></p> <p>"The safety of the program - the personal data, so nobody can access it" [38]</p>	<p>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.</p>
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## 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.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

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## APPENDIX 12: Search terms of the 2<sup>nd</sup> systematic review

<b>Search terms in MEDLINE, CINAHL PLUS, PsycINFO, EMBASE, CDSR</b>
1. "text messag*" or "online program*" or "mobile app*" or "mobile phone*" or "mobile phone*" or "mobile device*" or smartphone* or smart phone* or cell* phone or mhealth or "m health" or "mobile health" or ipad* or tablet or tablet PC or tablet computer or software or PDA or PDA phone or iphone* or ios or android
2. "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"
3. "randomi* controll* trial*" or RCT
<b>Search terms in ACM Digital Library</b>
1. smok* OR vape* OR e-cigarettes
2. stop* OR quit* OR cessation OR behave
<b>Search terms in IEEE Xplore</b>
1. stop* OR quit* OR cessation OR anti-vaping OR behavior*)
2. smok* OR vape* OR "e-cigarettes")
3. mHealth OR ehealth OR smart OR *health* OR app

APPENDIX 13 Military ranks (Source: Smoking Cessation Army)

<b>Military ranks</b>	<b>Required abstinence days</b>	<b>Rates in achieving this rank</b>
Soldier	0	N / A
Squad leader	1	43.15%
Platoon leader	3	30.71%
Company commander	7	23.72%
Battalion commander	15	17.55%
Regimental commander	31	13.66%
Brigade commander	63	9.57%
Division commander	127	5.91%
Corps commander	255	1.44%
Commander	511	0.77%
Supreme commander	1023	0.28%