The impact of e-cigarettes and individual-level interventions on socio-economic inequalities in smoking cessation

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Declaration

I, Loren Kock, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

The following work was carried out at the Department of Behavioural Science and Health, University College London, under the supervision of Dr Lion Shahab, Prof Jamie Brown and Dr Fabiana Lorencatto. This thesis has not been submitted, in whole or in part, for any other degree, diploma or qualification at any other university.

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Signed, 26th June 2020

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There are too many names to mention here, but thank you to all of the past and present comrades in room 208, and others on various floors of the Institute of Epidemiology and Health Care for making the PhD such an enjoyable experience. Thanks also to friends and housemates in London and elsewhere for keeping me distracted.

Thank you to my parents – Richard and Leelee – for your unfailing kindness and support, and for giving me the platform to pursue my interests. Thanks to Kara and James for the lockdown tennis and laughter, a welcome respite during this write-up. Also, thanks to Beau for the memorable adventures and for the many helpful and humorous chats in recent years. Finally, I would like to thank Jo for her encouragement and love, which has made the final year of my PhD a (nearly) painless experience.

Abstract

Electronic cigarettes (e-cigarettes) and individual-level interventions may either exacerbate or reduce inequalities in smoking cessation depending on differential effectiveness according to socio-economic position (SEP).

This thesis addressed three distinct but complementary objectives across five studies. First, study 1 involved a systematic review to examine whether interventions tailored for disadvantaged SEP moderated effectiveness for smoking cessation compared with non-SEP-tailored approaches. SEP-tailored interventions were no more effective than non-SEP-tailored interventions for smoking cessation among disadvantaged smokers.

Second, studies 2 and 3 modelled population-level trends in e-cigarette usage by SEP. Study 2 found that from 2014 to 2017 in England, e-cigarette use i) was greater among advantaged smokers compared with lower SEP smokers but this difference lessened over time, ii) was similar during a quit attempt across SEP groups, and iii) increased among all long-term ex-smokers but was more common among more disadvantaged ex-smokers. Study 3 examined the long-term ex-smoker sub-group from 2014 to 2019 in greater detail. Up until 2019 e-cigarette use continued to increase and diverge by SEP, with greater use among more disadvantaged groups. Separate analyses of ex-smokers who quit smoking before 2011 found a small increase in e-cigarette use over time but no evidence of differences by SEP.

The final, qualitative objective explored what lower SEP individuals thought about e-cigarettes for smoking cessation. Study 4 highlighted that participants were using an e-

cigarette in their otherwise unsupported quit attempt for health reasons, to save money, for family, and for enjoyment. Study 5 participants found an individual-level smoking cessation intervention involving the offer of an e-cigarette to be acceptable, and highlighted barriers and enablers to participation.

This thesis highlighted that SEP-tailored and non-SEP-tailored individual-level interventions are not currently equity positive, and that e-cigarettes could provide a route out of smoking for more disadvantaged and dependent smokers who cannot quit otherwise.

Impact statement

The key contributions of this PhD have been to update our knowledge about the trends in e-cigarette use across the socio-economic spectrum and to evaluate the effectiveness of smoking cessation interventions for disadvantaged smokers.

The programme of research presented in this thesis has led to collaboration with public health researchers at other institutions including the Universities of Bath, Bristol and Aberdeen. Outside of academia, the set up and management of the E-ASSIST RCT has led to the development of good working relationships with tobacco control leads and practitioners at participating stop smoking services, creating opportunities for future collaboration and knowledge dissemination.

Regarding the potential impact on policy, following publication of an article based on Chapter 3 of this thesis, I was asked to present the findings to an audience of policymakers, researchers, practitioners and non-governmental organisations at a 2019 meeting of the Cancer Research UK E-Cigarette forum. My research has also contributed to the 2019 independent review of e-cigarettes and heated tobacco products commissioned by Public Health England.

A version of Chapter 2 was published in the Lancet Public Health. The work was presented as a poster at the 2018 Annual Meeting of the Society for Research on Nicotine and Tobacco (SRNT) Europe chapter in Oslo, and presented orally at the 2019 international Annual Meeting of SRNT in New Orleans.

The details of the peer-reviewed article are as follows: Kock, L., Brown, J., Hiscock, R., Tattan-Birch, H., Smith, C., & Shahab, L. (2019) Individual-level behavioural smoking cessation interventions tailored for disadvantaged socio-economic position: a systematic review and meta-regression. *The Lancet Public Health*, 4(12), e628-e644. DOI: 10.1016/S2468-2667(19)30220-8

A version of Chapter 3 was published in the journal Addiction, and was presented at the 2018 SRNT-Europe Annual Meeting in Munich. The details of the peer-reviewed article are as follows: Kock, L., Shahab, L., West, R. and Brown, J., 2019. E-cigarette use in England 2014–17 as a function of socio-economic profile. *Addiction*, 114(2), pp.294-303. DOI: 10.1111/add.14446

A version of Chapter 4 was published in The Journal for the American Medical Association (JAMA) Network Open and is due to be presented at the SRNT-Europe Annual Meeting in 2020. The details of the peer reviewed article are as follows: Kock, L., Brown, J. and Shahab, L. 2020. Association of socio-economic position with e-cigarette use among individuals who quit smoking in England, 2014 to 2019. JAMA Netw Open, 3(6). DOI: 10.1001/jamanetworkopen.2020.4207

I have also written disseminated findings from this thesis in the form of posts on the UCL Institute for Epidemiology and Health Care blog. Outside of academia, my research has been picked up by an online vaping news and advocacy website ‘ecigclick’ and Medical Xpress, a web-based medical and health news service.

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List of Abbreviations

BCT – Behaviour Change Technique

BF – Bayes Factor

CI – Confidence Interval

CO – Carbon Monoxide

COM-B – 'Capacity', 'Opportunity', 'Motivation', - 'Behaviour'

DBCI – Digital Behaviour Change Intervention

E-ASSIST – E-cigarette to Augment Stop-Smoking In-person Support and Treatment with varenicline

EMA – Ecological Momentary Assessment

EU - European Union

FCTC - Framework Convention on Tobacco Control

GRADE - Grading of Recommendations, Assessment, Development and Evaluations

HICs – High Income Countries

ITT – Intention-To-Treat

IC-SMOKE - Identifying effective behavioural components of Intervention and Comparison group support provided in SMOKing cEssation

LMICs – Low- and Middle-Income Countries

MI – Motivational Interviewing

MPOWER – 'Monitor tobacco use and prevention policies', 'Protect People from Tobacco Smoke', 'Offer help to quit tobacco use', 'Warn about the dangers of tobacco', 'Enforce bans on tobacco advertising, promotion and sponsorship', 'Raise taxes on tobacco'

NA – Nucleus Accumbens

NAChRs - Nicotinic Acetylcholinergic Receptors

NCSCT - National Centre for Smoking Cessation and Training

NHS – National Health Service

NRT – Nicotine Replacement Therapy

OR – Odds Ratio

OSF – Open Science Framework

PATH – Population Assessment of Tobacco and Health

PRIME – ‘Plans’, ‘Responses’, ‘Impulses’, ‘Motives’, ‘Evaluations’

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses

RCT – Randomised Controlled Trial

RR – Risk Ratio

SE – Standard Error

SEP – Socio-Economic Position

SSS – Stop-Smoking Service(s)

STS – Smoking Toolkit Study

TFA – Theoretical Framework for Acceptability

TPD – Tobacco Products Directive

TQD – Target Quit Date

UCL – University College London

UK – United Kingdom

US/USA – United States of America

WHO – World Health Organisation

Contributions

Study 1 (reported in Chapter 2)

Dr Lion Shahab and Prof Jamie Brown, and Rosemary Hiscock from the University of Bath provided guidance in the development of the research question for this study and provided feedback on the draft that was submitted for publication. To check reliability Charlie Smith and Harry Tattan-Birch (PhD students at UCL) provided some assistance with the screening of studies for inclusion in the review and with data extraction. I developed the data extraction form and extracted all data, conducted all analyses and wrote all versions of the chapter myself. Dr Lion Shahab and Prof Jamie Brown contributed to and approved the final draft of this chapter.

Study 2 (reported in Chapter 3)

Dr Lion Shahab and Prof Jamie Brown provided guidance in the development of the research question for this study and provided feedback on the draft that was submitted for publication. I managed the dataset, conducted all analyses and wrote all versions of the chapter myself. Dr Lion Shahab and Prof Jamie Brown contributed to and approved the final draft of this chapter.

Study 3 (reported in Chapter 4)

Dr Lion Shahab and Prof Jamie Brown provided guidance in the development of the research question for this study and provided feedback on the draft that was submitted for publication. I managed the dataset, conducted all analyses and wrote all versions of the chapter myself. Dr Lion Shahab and Prof Jamie Brown contributed to and approved the final draft of this chapter.

Study 4 (reported in Chapter 5)

Dr Lion Shahab and Prof Jamie Brown provided guidance in the development of the research question and conduct of research for this study. I analysed all the data and wrote all versions of the chapter myself. Dr Lion Shahab and Prof Jamie Brown contributed to and approved the final draft of this chapter.

Study 5 (reported in Chapter 6)

Dr Fabiana Lorencatto, with support from Dr Lion Shahab and Prof Jamie Brown provided guidance in the development of the research question for this study, Harry Tattan-Birch provided assistance with the coding of interview transcripts and discussion of codes and themes generated from the qualitative data. I analysed all the data and wrote all versions of the chapter myself. Dr Fabiana Lorencatto, Dr Lion Shahab and Prof Jamie Brown contributed to and approved the final draft of this chapter.

Summary of thesis

Using mixed methods this thesis reports five studies under three distinct but complementary objectives.

The first objective concerned the effects of individual-level interventions in socio-economically disadvantaged groups and included one study. Study 1 (reported in Chapter 2) was a systematic review of 42 RCTs that assessed whether tailoring interventions for lower SEP moderated effectiveness for smoking cessation compared with interventions that were not tailored for any specific socio-economic group. There was moderate certainty evidence that both SEP-tailored and non-SEP-tailored individual-level interventions were found to be effective for smoking cessation, but there were no large moderating effects of SEP-tailored interventions. There was low certainty evidence that the effects of non-SEP-tailored interventions were similar among low-SEP and high-SEP participants. Improvements in the design and delivery of SEP-tailored individual-level interventions are likely to be necessary if they are to achieve equity-positive smoking cessation outcomes.

The second objective consisted of two studies that used representative cross-sectional survey data of adults age 16+ in England from the Smoking Toolkit Study (STS) to model population-level trends in e-cigarette usage by SEP. Study 2 (reported in Chapter 3) used data from 81,067 respondents to examine whether there were any associations between SEP and e-cigarette use from 2014 to 2017 among four key subgroups: i) all adults, ii) past-year smokers, iii) smokers during a quit attempt and iv) long-term (>1-year) ex-smokers. E-cigarette use was greater among adults of lower SEP adults compared with

adults of higher SEP. Among past-year smokers a socio-economic gradient in e-cigarette use ran in the opposite direction with e-cigarette use more prevalent among more advantaged respondents. This socio-economic differences in use among past-year smokers reduced over time and appeared similar in 2017. There were no significant differences in e-cigarette use during a quit attempt by SEP throughout the entire time period. The use of e-cigarettes by long-term ex-smokers increased over time overall but was consistently more common among those from lower SEP groups.

The apparent association between e-cigarette use and SEP among ex-smokers warranted further investigation as it may yield insights into the impact of e-cigarettes on smoking-related inequalities. Study 3 (reported in Chapter 4) included data from 34,442 respondents and assessed trends in e-cigarette use by SEP from 2014-2019 among i) all long-term ex-smokers (quit smoking for >1 year), ii) past-year ex-smokers who did not use an e-cigarette in their most recent quit attempt (representing recent uptake of e-cigarettes), and iii) long-term ex-smokers who quit smoking before e-cigarettes became popular in 2011 (representing late uptake of e-cigarettes). E-cigarette use was found to increase among long-term ex-smokers but was highest among those of lower SEP. Among those who quit smoking in the past year but did not use an e-cigarette to do so there was no clear trend over time or any socio-economic difference in post-cessation uptake of e-cigarettes. Finally, among those who quit smoking before 2011, there was no evidence for an association between SEP and e-cigarette use.

The third objective involved two studies exploring e-cigarette use among lower SEP individuals in the context of unsupported and supported smoking quit attempts. Study 4 (reported in Chapter 5) was a mixed methods study involving nine participants that explored patterns of e-cigarette usage and attitudes towards e-cigarettes in a smoking quit attempt. There was poor correspondence between self-reported and objectively recorded measures of e-cigarette use. Informed by the PRIME theory of motivation, one-to-one interviews found that participants were trying to quit smoking with an e-cigarette to improve their health, to save money, and for their family. E-cigarettes were seen by some as both a smoking cessation tool and a pleasurable activity, while others perceived the devices to be a tool and nothing more. Several participants described poor mental health being a limiting factor disrupting their ability to successfully quit smoking.

Study 5 was informed by the theoretical framework for acceptability (TFA) and the 'capacity', 'opportunity', 'motivation' – 'behaviour' (COM-B) and involved interviews with ten participants attending their local stop-smoking service (SSS). The interviews explored the acceptability of and barriers and enablers to an intervention offering an e-cigarette in addition to pharmacotherapy (varenicline) and behavioural support. The intervention was broadly found to be acceptable. Participants voiced positive affect towards their SSS advisor despite the burden of attending sessions and adhering to pharmacotherapy. Negative perceptions towards nicotine dependence discouraged long-term e-cigarette usage and influenced mixed opinions on whether they should be offered by SSS. Participants understood the intervention package to be complementary. Varenicline was thought to effectively reduce urges to smoke, and e-cigarettes helped to replace the habitual nature of smoking. Regarding enablers to participation, e-cigarettes were described as cheaper than cigarettes and more flexible to use, could replace the habit of smoking and were a back-up to prevent relapse. Family support was a key factor driving quit attempts. The harshness experienced by some participants due to lack of experience with vaping may be a barrier to device usage.

A general discussion (Chapter 7) reflected on these findings and commented on the overall strengths, limitations and implications of this thesis.

Chapter 1

General Introduction

Chapter Summary

Tobacco smoking remains a leading driver of morbidity and mortality globally, causing an estimated 8 million deaths in 2018. While the prevalence of smoking is declining in many high-income countries such as the United Kingdom, there are differences in use according to socio-economic position.

There are a range of evidence-based population-level and individual-level approaches to reducing smoking rates. These policies and interventions aim to arrest the uptake of cigarettes by those who have never smoked previously, and to increase cessation rates among current smokers. Population-level approaches refer to wide-scale structural changes such as tax increases, bans on tobacco sales and advertising. Individual-level interventions include behavioural support (delivered in-person, over the phone or digitally) and pharmacotherapy (medications such as nicotine replacement therapy and nicotine receptor partial-agonists, namely varenicline or cytisine). Both population-level and individual-level interventions have the potential to reduce or exacerbate existing inequalities in smoking cessation depending on differential impacts across the socio-economic spectrum.

Electronic cigarettes (e-cigarettes) confer lower levels of harm compared with smoking conventional tobacco cigarettes and are the most popular aid to smoking cessation in England. Evidence is growing in support of the devices as an effective tool to help people quit smoking. As such, e-cigarettes also have the potential to impact on inequalities in smoking cessation.

1.1 Tobacco smoking and nicotine dependence

Most commercial tobacco is a product of the cultivation and processing of the leaves of one species of tobacco plant, nicotiana tabacum. Tobacco is cultivated in over 125 countries, with the majority of leaf production taking place in China, India, Brazil, the USA and Turkey.[1] Cigarettes make up the majority of the world's output and consumption of tobacco, and are manufactured following a curing process that dries out the leaves and alters their chemistry in preparation for smoking. In 2017 over 80% of global market sales of cigarettes were controlled by five transnational tobacco companies: China National Tobacco Corporation, Philip Morris International, British American Tobacco, Japan Tobacco Inc. and Imperial Tobacco.[2]

Tobacco smoke is a toxic mixture of over 5,000 chemicals, 98 of which are risk factors for the development of cancers and cardiovascular and respiratory diseases.[3] Nicotine, the addictive component of tobacco smoke, likely only plays a minor role, if at all, in smoking-related disease.[4,5] Once inhaled, nicotine passes through the lungs and is rapidly absorbed into the bloodstream and reaches the brain within seconds, before binding to nicotinic acetylcholinergic receptors (nAChRs) in the ventral tegmental region and exerting complex effects on multiple neural pathways. NAChRs are a ubiquitous form of ligand-gated ion channel on the surface of neurons.[6,7] Binding of nicotine opens the ion channels and allows sodium and calcium to enter the cell, leading to bursts of firing along the neural pathway that extends to the nucleus accumbens (NA). These signals stimulate the release of dopamine and other neurotransmitters in the shell and core of the NA that are involved in the brains pleasure and reward circuits.[8] Symptoms of craving and withdrawal are thought to result – in part - from desensitisation of nAChRs. After prolonged and repeated stimulation by nicotine, as is typical for daily smokers, there is a decrease in the biological response to the chemical, known as desensitisation. This leads to greater tolerance for nicotine, whereby a greater amount of the chemical is required to produce the same initial effect. The brain responds to this by upregulating nAChRs. While acute nicotine exposure increases dopamine release, there is evidence that chronic exposure to nicotine causes lower basal levels of dopamine and other neurotransmitters.[9,10] These lower concentrations of neurotransmitters involved in the pleasure and reward circuitry of the brain are associated with the anhedonia experienced during a quit attempt. Maintaining sufficient levels of plasma nicotine likely prevents withdrawal symptoms and delivers rewarding effect from the conditioned reinforcements associated with smoking.[4]

Relief from withdrawal symptoms is therefore likely the main reason for feelings of stress relief and improved performance after an individual has had a cigarette.[8] The behavioural component of nicotine addiction emerges after regular smoking when a smoker begins to associate certain moods, situations or environmental cues with the mood modulating and pleasurable effect of nicotine.[4]

The behavioural aspects of cigarette addiction can also be understood through PRIME theory, a general theory of motivation. According to PRIME theory[11], addiction is defined as "*a chronic condition involving a repeated powerful motivation to engage in a rewarding behaviour, acquired as a result of engaging in that behaviour, that has significant potential for unintended harm*". PRIME stipulates that an interacting chain of motivational subsystems contribute to motivation for a given behaviour. This system includes Plans (related to future actions, commitments and a starting position), Responses (organises and executes responses to internal or external stimuli and/or the output of the sub-system), Impulses (experienced as urges when not resulting in an immediate action), Motives (consideration of the possible consequences of different actions) and Evaluations (ideas about the world resulting from what an individual believes to be true). It is the instability and interaction between these different levels in the motivational system, combined with the dynamic stimuli that individuals are exposed to that motivate smoking at any given moment. This interplay of molecular and behavioural events is what constitutes addiction to cigarettes, and treatment of this addiction seeks to disrupt the cycle by reducing impulses to smoke and increasing individual motivation and capacity to resist these impulses.

1.2 The global tobacco epidemic

Tobacco smoking remains one of the leading causes of preventable mortality worldwide, with total deaths caused by cigarette smoking (largely attributed to lung cancers and cardiovascular disease) estimated to be 8 million in 2018.[12] Smoking prevalence and cigarette consumption have followed heterogeneous trajectories in different countries and regions worldwide due to varying complex systems of tobacco control policy, tobacco industry influence, and differing population demographics and cultures.[13] Stratifying overall cigarette consumption by WHO region reveals that from 1999 to 2016 the Chinese population consumed near half of all cigarettes globally.[14] Over the same time-period consumption plateaued and then steadily declined in other regions such as Europe and the Americas.

Smoking rates generally peaked during the 1960s and 1970s in high-income countries (HICs) and have since declined fairly consistently.[15] This is largely due to stronger tobacco control measures in response to the irrefutable evidence around smoking as a major cause of disease and mortality. However, smoking rates are likely to increase still in many low- and middle-income countries (LMICs). This overall increase in cigarette consumption will be a result of rapid economic development and population growth in the context of weaker tobacco control regulatory environments; conditions that favour the expansion of the tobacco industry. In 2003 the world's first global public health treaty, the WHO Framework Convention on Tobacco Control (FCTC) was negotiated to arrest the growing tobacco epidemic.[16] The FCTC outlines policy measures such as tobacco taxation and advertisement restrictions, and requires countries to establish essential infrastructure for tobacco control. In line with the FCTC, the Bloomberg initiative created a package of tobacco control intervention guidance and grant awards called MPOWER[17], which largely targets LMICs. Despite these measures, it has been estimated that the considerable between-country disparities in smoking will continue into 2025 if current trends persist, with many LMICs not set to achieve FCTC targets.[18] Relatively recent estimates of smoking prevalence by different global regions are outlined in Table 1.1 and in particular highlight the disparity in prevalence between men and women both overall and in specific regions such as Eastern and South-eastern Asia. However, different countries are known to use varying definitions for smoking status[19] so these estimates should be interpreted with caution.

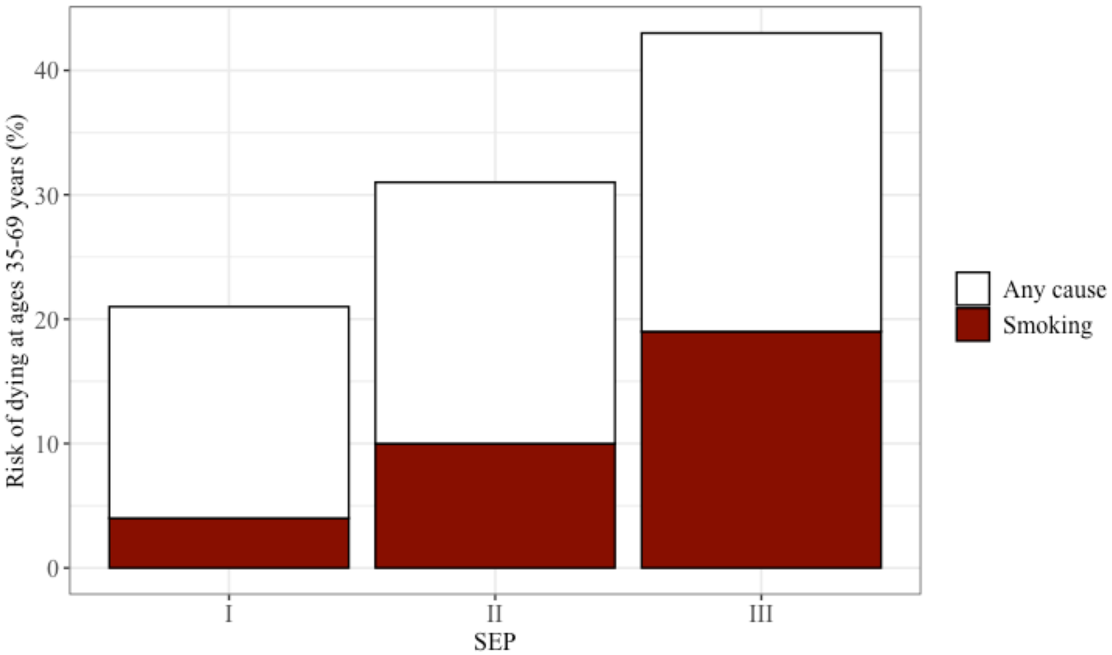
Table 1.1: Global tobacco smoking prevalence by region and sex[20]

Region	Overall % (95% CI)	Men % (95% CI)	Women % (95% CI)
Africa	13.0 (9.5-17.5)	23.0 (16.0-30.5)	3.0 (2.0-5.0)
Caribbean, C. and N. America	13.0 (8.0-16.0)	20.0 (12.0-24.0)	4.0 (2.0-8.0)
South America	21.0 (17.3-28.8)	30.0 (27.5-39.3)	14.5 (6.5-20.3)
C. S. and W. Asia	23.0 (16.0-26.0)	37.0 (31.0-42.0)	4.0 (2.0-9.0)
East and South-east Asia	23.5 (22.0-26.8)	45.0 (39.0-47.8)	3.5 (2.3-6.8)
Eastern Europe	30.5 (28.8-36.8)	41.5 (38.0-49.3)	22.0 (20.0-25.5)
Northern Europe	27.0 (23.0-31.5)	28.0 (23.5-43.0)	22.0 (20.0-25.5)
Southern Europe	28.0 (24.8-33.5)	34.5 (30.8-44.5)	24.0 (17.3-27.8)
Western Europe	28.5 (26.0-38.5)	33.0 (30.5-40.8)	24.0 (22.8-35.8)
Oceania	19.0 (20.8-43.5)	43.0 (32.3-52.8)	19.0 (11.0-29.5)
Overall	22.5 (15.0-27.0)	32.0 (23.3-43.0)	7.0 (3.0-19.8)

Source: WHO Global Health Observatory data repository (2014), adapted from http://apps.who.int/gho/data

In most countries, smoking rates are socio-economically patterned with greater prevalence among those of more disadvantaged socio-economic position (SEP).[21] In some LMICs at earlier stages of the tobacco epidemic cigarette, consumption is determined by affordability. However, this pattern is not true of all countries irrespective of income or development status.[22] This ultimately leads to disadvantaged groups bearing a disproportionate burden of smoking related morbidity and mortality. For instance, analyses from death rates in Western Europe and North America have estimated that most of the social inequalities in adult mortality in the 1990s can be attributed to smoking.[23] Data for England and Wales during this period is shown in figure 1.1.

Figure 1.1: Social inequalities in male mortality in 1996 from smoking and from any cause[23]

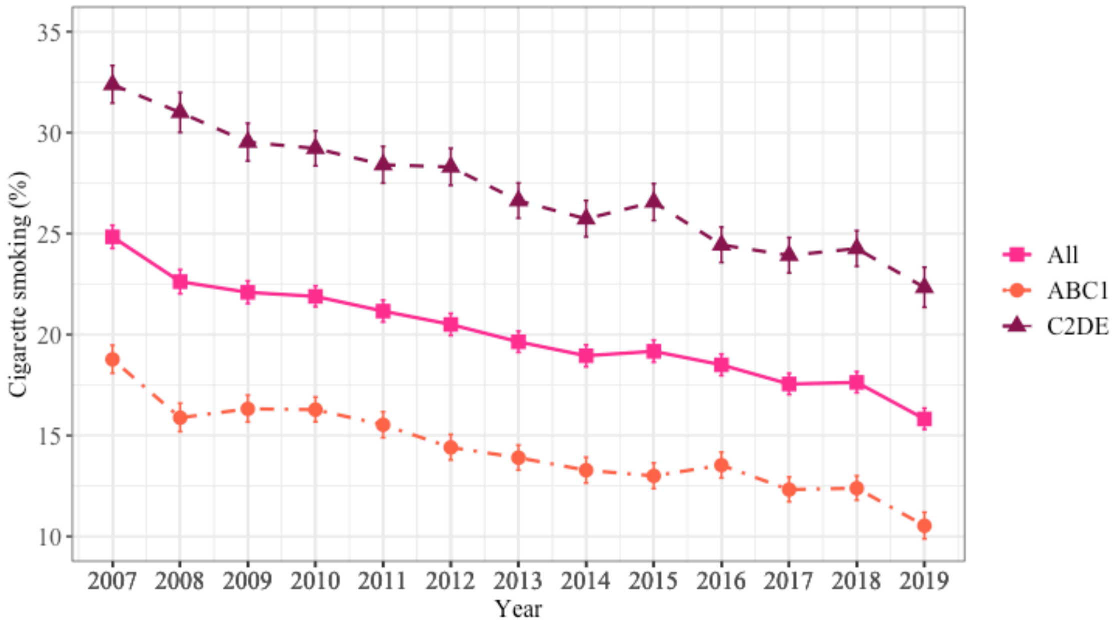


Percentages of 35-year-old men dying at ages 35–69 years from smoking (red) or from any cause (red and white). I = "High" SEP; II = "Mid" SEP, III = "Low" SEP

1.3 Socio-economic position and smoking in England

SEP broadly refers to the social and economic position that an individual occupies within society relating to their occupation, income, wealth, education and social status.[24] 'Disadvantaged' or 'low/lower' SEP individuals are categorised as those who in general have lower levels of income, education, housing status (i.e. community or social housing rental), experience local neighbourhood deprivation and have routine and manual occupations.[25] The term 'disadvantage' in this thesis is therefore operationalised using such variables related to SEP. Data from the Health Survey for England (HSE), Office for National Statistics (ONS) and other sources have estimated smoking prevalence in England to be 14.4% among all adults, down from 15.5% in 2016 and 19.8% in 2011.[26] Despite this progress, smoking prevalence is not equally distributed across the socioeconomic spectrum. Smoking is highest among those of more disadvantaged SEP compared with more advantaged groups. Using social grade based on occupation as a proxy for SEP, the smoking toolkit study (STS)[27] estimates that smoking rates are currently 22.3% among those with routine and manual occupation compared with 10.5% among higher professional and managerial occupations (Figure 1.2).

Figure 1.2: Annual prevalence of cigarette smoking in England 2007-2019



ABC1: Professional and clerical occupations; C2DE: Routine and manual occupations. Weighted data form the STS

This broadly corresponds to data from NHS Digital which estimated prevalence of 10% among those with higher professional and managerial occupations compared with 25% among those in routine and manual occupations. These socio-economic inequalities have persisted during a period in England in which overall smoking prevalence declined from 24% in 2007[28] to 14.4% in 2018.[26] Disparities in cessation and uptake have led to smoking becoming one of the leading causes of health inequalities among socio-economically disadvantaged groups[29], who suffer a disproportionate burden of the mortality and morbidity attributable to smoking. Most research has shown that compared with more advantaged individuals, those of disadvantaged-SEP face more facilitators to smoking uptake (particularly relevant for youth uptake as tobacco use typically begins in childhood or adolescence[30]), and more barriers to quitting (Table 1.2). Moreover, while smokers attempt to quit at similar rates across the social spectrum, disadvantaged-SEP smokers are less likely to succeed in a quit attempt.[31] In the context of these persistent disparities, it is the primary aim of this thesis to better understand how the evolving landscape of technologies and interventions impact on these existing socio-economic inequalities in smoking cessation, and whether they can play a role in reducing them.

Table 1.2: Proposed key determinants of smoking uptake and cessation in socio-economically disadvantaged groups. Adapted and updated from previous reviews.[45]

Smoking uptake	
Parental smoking	Parental smoking status (more prevalent in disadvantaged adults) is a predictor of youth smoking uptake.[32]
Peer group	Disadvantaged youths are more likely to smoke[33] and may be less able to resist peer pressure.[21]
Awareness of harms	Disadvantaged youths may have lower awareness of and underestimate harms from smoking.[21]
Social problems	Disadvantaged youth are more likely to experience psycho-social problems related to familial or educational stress which increases the risk of initiation.[34]
Educational performance	Disadvantaged youth are likely to have poorer educational performance which is a predictor of smoking status.[35]
Access to tobacco products	The availability of tobacco products is greater in disadvantaged neighbourhoods.[36,37]
Smoking Cessation	
Nicotine dependence	Disadvantaged smokers have been found to be more dependent on nicotine.[38,39]
Motivation	Less likely to intend to quit and may discount present value of the reward of cessation because of delay in the manifestation of harms.[40]
Social support	It has been suggested that disadvantage is associated with less social support and participation which may reduce the success of quit attempts.[41,42]
Stress	Disadvantaged smokers are more likely to highlight being nervous, restless or depressed as a reason for relapse to smoking.[43]
Self-efficacy	Disadvantage is associated with lower self-efficacy to quit smoking.[39]
Tobacco industry targeting	The tobacco industry is known to target potential smokers from disadvantaged communities.[44]
Treatment adherence	Poor adherence to stop-smoking medications and behavioural support, however the direction of causality remains to be assessed.[45,46]

1.4 Health inequalities research

Reducing the uptake of cigarettes and supporting people to quit smoking is an important area of health inequalities research. Health inequality refers to differences in ill health and mortality between people according to various measures of socio-economic position such as income, occupation, education, housing situation and prestige ('standing in the community').[47]. Today, research into health inequalities is conducted in many countries around the world, and often intersects with other areas of research into the social determinants of health such as gender and race/ethnicity. Although widespread today, heath inequality as a subject of academic research and public policy emerged in the UK in 1980 following publication of the Black Report by the then Department of Health and Social Security.[48] Using data on occupation from death certificates and the population census, the Black report highlighted that between the 1950s and the 1970s the likelihood of death at most ages was strongly associated with social class ('general standing in the community based on occupational skill'), a measure of socio-economic position. This social patterning of morbidity and mortality persists today. Published in 2020, the updated Marmot review has confirmed that deprivation is associated with shorter life expectancy and that, over the past decade, the social gradient has increased.[49] Working to understand and alleviate these inequalities remains a focus of public health research and policy.

1.5 Interventions for smoking cessation

Interventions to assist people in quitting smoking can broadly be categorised according to whether they act at the level of the population or the individual.

1.5.1 Population-level interventions

Population-level tobacco control interventions are those that affect populations, groups, areas, jurisdictions or institutions and generally require control from the state or other large institutions. The aim of such interventions is to change societal structures (social, physical, economic or legislative environments) to reduce smoking uptake and encourage people to quit. Major population-level interventions that have been implemented in recent decades include advertising restrictions, health warning labels, banning smoking in public places, increasing the tax on tobacco products and age of sale restrictions.[50] Population-level interventions have the potential to reduce health inequalities if they have a greater impact on reductions in socio-economically disadvantaged communities compared with more advantaged groups.[50] Increasing the price of tobacco through taxation is often cited as an equity-positive population-level approach to reduce smoking rates, and has recently been shown in Australia to have especially strong and immediate effects among socio-economically disadvantaged groups.[51] However, the rebounding of smoking rates in these groups over-time suggests that other policies and interventions need to be structured so as to prevent relapse to cheaper products such as roll-your-own tobacco. The importance of population-level interventions cannot be understated but is not the focus of this PhD.

1.5.2 Individual-level interventions for smoking cessation

Individual-level interventions are often clinically approved and provided by trained healthcare professionals. They can involve the use of pharmacotherapy or individualised or small group behavioural or cognitive interventions to encourage smoking cessation.[52] This group of interventions seeks to address the neurobiological and behavioural mechanisms associated with the release of nicotine from cigarettes (section 1.1) that are behind the failure of an attempt to quit smoking. They do so by combating the difficulties that an individual faces during a quit attempt such as nicotine withdrawal[53] and urges to smoke at times or places where the individual smoked previously.[54] Without support during a quit attempt around 50% of people relapse to smoking within the first week of abstinence.[55]

Even with the most effective behavioural support and pharmacotherapy for smoking cessation, the majority of smokers who make a quit attempt do not remain abstinent in the long-term (six months to a year after quitting).[56,57] Considering that smoking is a leading preventable cause of ill health it remains an important goal in public health to support smokers and improve their chances of quitting smoking and remaining abstinent in the long-term. The evidence for the different individual-level interventions will be discussed in turn. This thesis is focussed on the interventions that directly address cigarette addiction at the individual level. However, this does not detract from the importance of population-level smoking cessation programmes. Rather, both approaches are closely related to each other in a complex system of tobacco control and population health that involves feedback between individual agents, the broader system and the changes that occur within it.[58]

1.5.2.1 Behavioural support

Individual behavioural support for smoking cessation can be delivered in several forms including in-person, over the telephone, on a digital platform or in print, and can be delivered concurrently with pharmacotherapy.

In-person counselling

Run by the local borough or county council in the UK, specialised and free at the point of access stop smoking services (SSS) deliver one-to-one individual behavioural support for adults who are trying to quit smoking. Advisors trained in assisting smoking cessation deliver a programme of behavioural support to smokers, closely aligned with guidance from the National Centre for Smoking Cessation and Training (NCSCT).[59] Standard SSS support typically starts with a pre-quit session, where counsellors set a target quit date

(TQD) with their smoking client and continue to see them at regular intervals from this day until at least 4 weeks post-TQD. Some services continue to see clients until 12 weeks post-TQD. A client's smoking abstinence is measured at every session following the TQD but specifically at four weeks post-TQD (a requirement for reporting to the NHS).[59] Abstinence is self-reported by a client and in most cases biochemically verified using an expired carbon monoxide (CO) monitor.[60] CO is released in the burning of tobacco. A threshold of 8-10 parts per million (ppm) is a good indicator of recent smoking because levels above this threshold can be detected in expired air for around one day with high accuracy. A recent review from the Cochrane database of systematic reviews found high-quality evidence from randomised controlled trials (RCTs) that individual counselling for smoking cessation was more effective than a minimum contact control (Risk Ratio (RR) 1.57, 95% confidence interval (CI) 1.40 – 1.77) at achieving abstinence at 6 months following a quit date.[61] The authors also reported medium quality evidence for the same direction of effect in studies where pharmacotherapy was included as part of both the intervention and usual care arms of the trial (1.24, 95% CI 1.01 – 1.51). Group counselling is also used in the context of SSS[62], but given that sessions involve several people rather than a one-to-one interaction between a counsellor and a smoker, it will not be subject to analysis within this thesis.

Motivational interviewing (MI) is another form of behavioural support that has been utilised in smoking cessation treatment and is performed by health professionals or smoking cessation counsellors. The aim of MI in this context is to help smokers resolve insecurities and feelings of ambivalence towards their behaviour in order to find the internal motivation needed to quit.[63] The technique may increase in quitting rates, and with a greater effect size if delivered by primary care physicians (RR 3.49, 95% CI 1.53

– 7.94) than with smoking cessation counsellors (1.25, 95% CI 1.15 – 1.64), compared with brief advice or usual care.[64]

Nurses make up the largest workforce in the UK health system.[65] Nursing-delivered interventions consist of brief interventions, counselling and strategies to help an individual quit smoking, and have been shown to be effective when compared with a control (no intervention) or usual care.[66] Similarly, physician advice may be brief, or part of a more intensive smoking cessation intervention, and may be integrated with a consultation for specific diseases related to smoking.[67,68] There is evidence that physician advice improves quit rates compared with no advice or usual care, and appears effective when delivered in a minimal or intensive fashion.[69]

Specialist in-person stop smoking support can deliver a range of evidence based behaviour change techniques (BCTs)[70] to smokers trying to quit. These BCTs can be generally categorised under i) boosting motivation to quit, ii) improving skills and capacity for self-regulation, iii) promoting the use of cessation medications and iv) other supporting activities. However, evidence suggests that there is wide variation and low fidelity in the content of BCTs delivered in English SSS.[71,72] This is an important consideration given that the efficacy of these interventions for smoking cessation might be more dependent on certain BCTs relative to others.[73] Therefore, routine monitoring may be necessary to ensure that SSSs adhere to intervention protocols and also allow research into the relative effectiveness of different BCTs in the SSS setting. Nonetheless, there is consistent evidence that individual counselling from trained stop smoking counsellors and health professionals can assist smokers to quit.[74] Furthermore, when given as an adjunct to pharmacotherapy it can deliver a small but important improvement in smoking cessation compared with pharmacotherapy alone, and this appears to follow a dose-response relationship.[75]

Although the different modes of one-to-one support that have been discussed appear to improve quit rates in clinical practice, they are more resource intensive and have potentially lower overall population reach than interventions delivered using other means such as telephone counselling or digital platforms. Investment into SSS in the UK has fallen in recent years, from £70.2 m in 2016–17 to £60.3 m in 2018–19.[76] As a result, services face the challenge of continuing to deliver behavioural and pharmacological support to smokers making a quit attempt, despite having fewer available resources.

Telephone support

Smoking cessation support can be delivered over the telephone in the form of helplines or ‘quitlines’ with a specialist advisor. Calls may be initiated by the smoker, or involve call-back or outreach by the quitline service. This method of support does not require the same level of time and travel organisation as appointments for in-person support and so can potentially reach more smokers. Telephone support can also deliver the programme of BCTs for smoking cessation that are present in face-to-face counselling.[77,78] However, as with in-person counselling it is possible that telephone behavioural support is not delivered consistently or in line with recommended practice.[72] When compared with minimal support or usual care, telephone support (three or more calls) is estimated to improve smoking quit rates.[79]

Digital behaviour change interventions

Digital behaviour change interventions (DBCIs) for smoking cessation are those delivered on any digital technology platform. This includes support delivered using internet websites, mobile phones, smartphone applications and wearables. Eighty-nine percent of adults in Great Britain use the internet at least weekly[80], and 85% adults own or have access to a smartphone.[81] Digital technology has the potential to reach a greater number of smokers compared with other methods, and allows providers to tailor responses to individual user needs in real-time during a quit attempt.[82] Growing evidence suggests that tailored internet-based interventions for smoking cessation are more effective compared with non-active controls.[82,83,84] However, effect estimates from meta-analyses are interpreted with caution due to substantial statistical heterogeneity in the calculation of pooled-study effect estimates. When compared with active smoking cessation treatments, the most recent Cochrane review on this topic found no evidence of effectiveness of internet plus behavioural support.[84]

Mobile phone-based interventions (applications or messages/reminders sent through a mobile phone), appear to have a beneficial impact on smoking cessation. The most recent Cochrane review of mobile phone text messaging and app-based interventions for smoking cessation concluded that automated text message-based smoking cessation interventions can boost quit rates compared with minimal smoking cessation support.[85] However, more RCT evidence is needed to assess the benefits of smartphone apps compared with less intensive support.

DBCIs have great potential to reach a large proportion of smokers who do not have access to or wish to attend in-person SSS behavioural support, but challenges remain in the form of maintaining user-engagement with the platform in the context of other applications and web platforms that are competing for the attention of a user. As such, understanding and predicting user-engagement with digital technologies for smoking cessation is becoming an increasingly important area of research.[86,87,88]

Print-based self-help interventions

Print-based self-help materials provide structured smoking cessation advice in the form of leaflets or informational booklets for smokers who are looking to quit. While often delivered concurrently with other forms of behavioural support, it is estimated that when delivered on their own, print materials increase quit rates compared with no intervention, albeit with a small effect size.[89]

Incentives

Material and financial incentives are known to promote a range of health improving behaviours, and can be delivered in a range of contexts such as hospitals and places of work. For smoking cessation, these incentives have also been shown to be effective both while they are in place and in the longer-term after they have been withdrawn.[90] However, the most effective methods to deliver health incentives remain uncertain, with some recent evidence for reward-based programmes having greater sustained abstinence compared with deposit/commitment-based programmes (where participants place some of their own money at risk and re-gain it on the condition of a successful behavioural outcome).[91,92]

1.5.2.2 Pharmacotherapy

Pharmacotherapy includes medications that act to dampen craving and withdrawal symptoms, reduce nicotine reinforcement. Where available, the three first line treatments for smoking cessation include nicotine replacement therapy (NRT), nicotine receptor partial agonists (varenicline and cytisine) and the anti-depressant buproprion.[93]

Nicotine Replacement Therapy (NRT)

NRT was developed as a safer substitute to smoking by permitting absorption of nicotine into the bloodstream to satisfy craving, without the toxic mixture present in tobacco smoke. It was the first effective medication for the treatment of tobacco addiction.[94] NRT is available in a fast-acting formulations that are delivered orally (in the form of gum, lozenges, nasal spray, mouth spray, film, inhaler, or tablet), or as a slower acting transdermal nicotine patch.[95] There is good evidence that all forms of NRT are effective and improve the chances of successful quit attempts, increasing quit rates by 50% to 60%. Dual-form NRT, which combines slow and fast-acting formulations is most effective for quit success at least in the short term.[96] Faster acting NRTs appear helpful in satiating the positive effects of nicotine administration through smoking and reducing acute craving, whereas the slow-acting formulation nicotine patches supply constant lower levels of nicotine which when dosed correctly can reduce withdrawal symptoms.

Nicotine receptor partial agonists

Nicotine receptor partial agonists became a viable option for treatment of cigarette addiction with the discovery that high affinity a4b2 nAChRs in the mesolimbic dopamine system mediate the effects of nicotine in the brain.[97] Activation of these receptors triggers the downstream release of dopamine and the aforementioned reward and pleasure signals. Mouse gene knockout studies showed that when the a4 or b2 subunits are removed, the pharmacological and behavioural effects of nicotine are attenuated.[98] Furthermore, when b2-knockout mice underwent targeted expression of the b2 subunit, nicotine seeking behaviour and induced dopamine release resumed.[99] These findings supported the hypothesis that targeting the a4b2 nAChRs in the brain with a partial agonist (displaying concurrent agonist and antagonistic properties[100]) would reduce both nicotine craving and withdrawal symptoms in smokers attempting to quit. The naturally occurring plant compound cytisine and its synthesised chemical analogue varenicline are two such nicotine receptor partial agonists, and are used widely in different countries depending on licensing laws. Varenicline, currently licensed for use in the US and most countries in the European Union, has been shown to at least double the chances of successful long-term smoking cessation compared with controls without pharmacotherapy.[101] Varenicline was also shown to be more effective for smoking cessation than single-form NRT or bupropion. Trials with cytisine indicate a superior effect over NRT for smoking cessation,[102,103] and given its lower cost warrants being licensed more widely outside of Eastern Europe. Drug companies that manufacture cytisine, a generic drug, are not currently incentivised to conduct the required placebo-controlled trials in the US and Western Europe. Pfizer, the manufacturer of Varenicline, will lose its patent for the drug between 2020 and 2021 in the US and UK, respectively. Whether or not regulatory authorities will license cytisine in the near future as an in-class competitor for varenicline remains to be seen.

Antidepressants

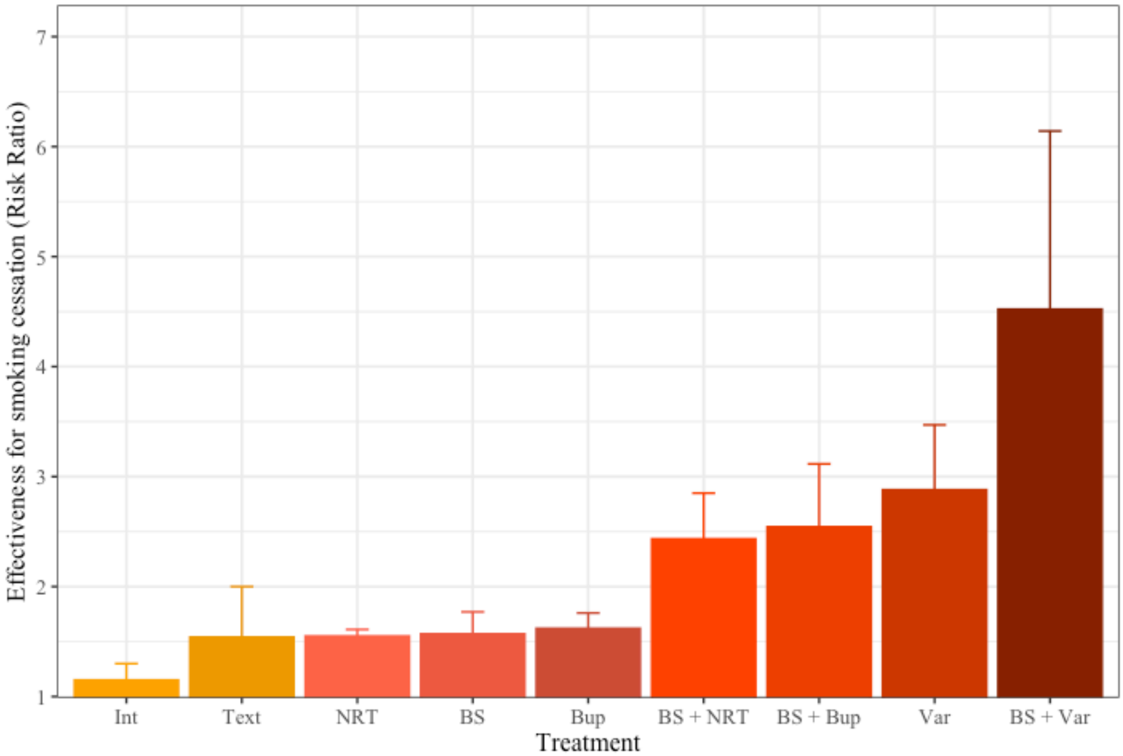
Smokers with a history of major depressive disorder are more likely to be dependent on nicotine and less likely to successfully quit smoking compared with individuals who have never experienced depression or have no psychiatric diagnosis.[104] It is thought that the neurochemical effects of antidepressants, such as the release of dopamine and serotonin in the brain, are similar to those of nicotine thus making them suitable candidates to support smoking cessation.[4] The two most widely tested antidepressants for smoking cessation are bupropion and nortriptyline. Both drugs have been shown to aid long-term smoking cessation, and with a similar efficacy to that of single-form NRT.[105]

Combined pharmacotherapy and behavioural interventions

When delivered independently, behavioural support and pharmacotherapy are effective in supporting a quit attempt. Given this knowledge, research has been conducted to assess the benefits of concurrent treatment with pharmacotherapy and behavioural support. Evidence indicates that combined therapy increases smoking cessation rates compared with usual care or a minimal intervention.[106] This evidence has been supported by the National Institute for Clinical Excellence in the UK, and is currently the standard treatment protocol for UK specialist stop-smoking services.[107]

Using data from RCTs, Figure 1.3 summarises the effectiveness of some front-line individual-level interventions, and combinations of interventions for smoking cessation compared with no or minimal treatment.

Figure 1.3: Individual-level interventions – trial effectiveness.



Data from Cochrane database of systematic reviews; Int = internet-based intervention; Text = text-message based intervention; NRT = nicotine replacement therapy; BS = in-person behavioural support; Bup = Bupropion; Var = varenicline; bars represent risk ratios versus placebo (for medications) or no/minimum intervention (for behavioural support). 95% CIs based on risk ratios; figures for BS + NRT/Bup/Var involve multiplying effect of BS and effect of medication.[61,85,108,109]

1.5.3 Individual-level interventions and socio-economic inequalities in smoking cessation

Data from HICs show that mortality and morbidity rates are higher among those of more disadvantaged SEP, with smoking playing a major role in driving these inequalities.[23,110] There remains a social gradient in smoking with higher prevalence among disadvantaged populations who suffer a disproportionate burden of smoking-related disease and mortality compared with those of more advantaged SEP. In England overall, smokers who use a combination of behavioural support and pharmacotherapy in a quit attempt are three times as likely to succeed compared with those attempting to quit unassisted.[111]

However, all stages in the planning and delivery of a health intervention have the potential to widen inequalities between SEP groups in a target population.[112] While overall health outcomes improve, it may be evident for a given health intervention that disadvantaged groups do achieve less success compared with more affluent groups, resulting in an increase in health inequalities. These 'intervention-generated inequalities' should be considered when analysing the effect of specialist stop smoking support delivered by SSS in the UK. While low-SEP smokers are more likely to access SSS, they are less likely to be successful in their quit attempt[113], likely due to the additional barriers they face as a function of SEP (Table 1.2). This finding is supported by a review that examined the equity impact of tobacco control interventions that were not targeted specifically for low-SEP. The authors found consistent evidence of lower quit rates in low-SEP smokers who were accessing SSS.[114] This disparity is further compounded by evidence of differential prescription rates of front-line medications such as varenicline. A recent analysis has found that disadvantaged smokers attending UK SSS were less likely to be prescribed varenicline[115], the most effective form of stop smoking medication.

When services are targeted at socio-economically disadvantaged groups there is some evidence that this negative equity impact can be attenuated. This has been observed in a recent programme in Scotland where population quit success rates at three months were higher in the most deprived groups following a successful targeting campaign.[116] Although research into digital interventions for disadvantaged smokers is currently limited, a recent review of the evidence suggests that when delivered digitally, targeted smoking cessation support can also be effective at improving quit rates in socio-economically disadvantaged groups.[117] One specific trial conducted by members of the UCL Tobacco and Alcohol Research Group found an internet-based intervention to be more effective for smoking cessation in low but not high-SEP smokers.[118] Further research into improving access[119] and targeting is necessary in the context of major reductions in funding for SSS in England. Budget cuts occurred in an estimated 59% and 50% of SSS in 2016 and 2017 respectively, with some local authorities decommissioning SSS altogether.[120] Overall, investment in SSS has fallen by 14% over the past three years.[76]

1.6 Electronic cigarettes

Electronic cigarettes (e-cigarettes) are typically battery-powered devices that heat an element and vaporize a solution (e-liquid) that usually contains nicotine, propylene glycol, glycerine, flavourings and water. The aerosol released is inhaled by the user. E-cigarettes do not contain tobacco or involve combustion, and therefore do not produce smoke. There are several different types of e-cigarette, and the most common devices can be grouped into three categories: 1) Disposable (first generation); 2) Devices that can be-filled with e-liquid by the user (second generation); 3) Variable power devices where the user can manually regulate the power delivery from the battery to the element (third generation).[121] While the long-term effects of e-cigarettes on human health are not yet clear, and although not harmless, e-cigarettes are less harmful compared with smoking tobacco.[121] Concordant with previous research into the relative harm of e-cigarettes compared with tobacco smoking[122], recent lab studies have found that most e-cigarettes likely have cancer potencies of <1% that of tobacco smoke.[123] Despite the evidence that e-cigarettes are a safer method of nicotine delivery than tobacco smoking, only one third of current smokers perceive this to be true.[121]

1.6.1 E-cigarettes in the global context

E-cigarette use varies across countries worldwide due to differing cultures, market factors and tobacco control policy and regulation.[124] With support from WHO[125], e-cigarettes are currently banned in over 30 countries worldwide.[126] In the USA, UK and much of Western Europe e-cigarettes are available, subject to market authorisation from country governments. The general uncertainty among governments and the public around the world about the safety of e-cigarettes is driven by a contentious debate within public health. This debate is fuelled by disagreements within and between the countries where e-cigarette use is most common, namely the UK and the USA. The arguments and data driving these divergent positions on e-cigarettes will be discussed in section 1.6.5.

1.6.2 E-cigarette use in England

In England, e-cigarettes are widely available and regulated as consumer products under the European Union (EU) Tobacco Products Directive (TPD). Although this directive prohibits advertising on TV, radio, press, online and on social media, it does allow displays on outdoor posters and in the cinema.[127] Outside of the EU, restrictions on the sale and marketing of e-cigarettes vary by country. Laws in Norway, Singapore and Australia place severe restrictions on e-cigarette availability and diverge from the more favourable environments in the UK and USA where it is legal to sell e-cigarettes to adults.[128] These different situations are relevant because the potential of the devices to help smokers quit is likely dependent on the regulatory environment.[129] In line with the current scientific consensus in England, recent changes now allow advertising for e-cigarettes to be made in the context of being a safer alternative to tobacco smoking. However these advertisements are only permitted on mediums that are not already blocked by the TPD such as outdoor advertisements, on public transport, in cinemas and leaflets.[130] Since their arrival on the UK market in 2008/09, e-cigarettes have rapidly become the most popular aid used in a smoking quit attempt, with current use estimated to be >30% compared with 20% and <3% for over the counter NRT and varenicline respectively.[131] The STS estimates that after the initial rise at the start of the decade, growth in e-cigarette use has slowed and remained relatively stable since 2013 at around 5% prevalence in the general population.

1.6.3 Harm reduction

Harm reduction is a public health policy framework that aims to minimise the harmful physical and/or social consequences associated with recreational drug use, without necessarily reducing or eliminating use of the drug itself.[132] Compared with the general acceptance and adoption of harm reduction policies for illicit drug use (for instance needle exchange programmes), the approach has received more opposition in the tobacco control field. The harm reduction debate in the field of smoking and public health can be summarised by two general positions. Proponents argue that some smokers cannot or will not stop smoking, so alternative products that confer less harm are therefore beneficial to public health. Harm reduction opponents believe that the approach undermines the public health goal of preventing any form of tobacco use, and therefore exclusively promote cessation and prevention among youth.[132] As a cessation tool, pharmacotherapy is widely accepted as an effective means to reduce smoking rates. The same cannot be said for e-cigarettes. The devices are unique in that they are a recreational product and although they do not contain tobacco or involve combustion, simulate smoking behaviour. As evidence continues to emerge, the debate continues to track whether the devices confer significant harm to the user, and whether they are an effective tool for smoking cessation or, conversely, promote tobacco smoking.

1.6.4 E-cigarettes and smoking cessation

The result of a broad range of tobacco control policies and stop smoking interventions has been increased success rates in quitting smoking since 2011, and consistent decline in smoking prevalence in England since 2007.[131] Behavioural support and NRT increase the chances that an individual will have a successful quit attempt, but long-term abstinence rates are low[62,101] and these interventions do not appeal to all smokers. Conventional NRT delivers nicotine using transdermal or buccal absorption, but does not simulate any of the behavioural components of smoking. In contrast, e-cigarettes deliver a dose of nicotine but also simulate some of the sensory and behavioural aspects of smoking including the hand-to-mouth action, the inhalation and exhalation of vapour and the maintenance of a social identity.[133] The devices may therefore provide an easier route to smoking cessation for some smokers.[134] However, despite seemingly advantageous nicotine-delivery properties, for some users e-cigarettes are not always a satisfying substitute for tobacco smoking. Studies have reported a high number of dual users who use e-cigarettes and cigarettes concurrently. This behaviour may be related to differences in device type and efficiency of nicotine delivery; later generation tank models appear more effective than first generation “cigalike” devices[135,136] and has led to calls for continued innovation in device technology and improvements in access for smokers to quit using e-cigarettes.[137]

Results from recent RCTs suggest that e-cigarettes increase smoking cessation. When accompanied by behavioural support, e-cigarettes have been shown to be almost twice as effective for smoking cessation than NRT.[138] Furthermore, when in combination with nicotine patches, nicotine e-cigarettes boost quit rates compared with nicotine-free e-cigarettes plus patches, or patches alone.[139] This is supported by time-series data showing that, in England between 2007 and 2018, greater use of e-cigarettes during a quit attempt was associated with higher success rates.[140] These results highlight the substantial benefits that the devices may confer to population health by reducing the number of people smoking.

1.6.5 Concerns over e-cigarette use

Aside from uncertainty over the long-term health impacts of e-cigarette use[134], there are two main hypothesised concerns in tobacco control that have been raised regarding the use the devices for smoking cessation: 1) e-cigarette use undermines existing interventions in tobacco control and will reduce the rate of smoking cessation and 2) e-cigarette use leads to nicotine dependence in youth and act as a 'gateway' for never smoking youth to become smokers. These concerns are valid and warrant continuous monitoring to assess the extent to which e-cigarettes appear to be promoting or detracting from reduction in the prevalence of cigarette smoking. A recent time-series analysis in England found no clear association between e-cigarette use and prevalence of quit attempts or use of licensed NRT bought over the counter, prescription pharmacotherapy, or behavioural support. However, use of e-cigarettes in quit attempts was negatively associated with use of NRT on prescription.[141] A number of population studies at the individual-level have found a negative association or no association between e-cigarette use in the past and likelihood of smoking cessation.[142,143] However important mediators of quitting smoking such as frequency of use and the type of e-cigarette used were not considered in these studies.[136,144]

Studies looking at nicotine absorption from e-cigarettes among e-cigarette users found that participants lowered their concentration of nicotine e-liquid over time, but compensated by consuming more e-liquid.[145,146] This is important considering that while safer than smoking tobacco, the potential harms to health from e-cigarette use are likely due to exposure to formaldehyde and other carcinogenic compounds that are present in the aerosol generated from e-liquid.[147]

There remain concerns regarding the uptake of e-cigarettes by youth (broadly older children and adolescents aged 11-18).[148] Some longitudinal studies have claimed to provide evidence in support of a gateway effect for progression to cigarette smoking among never smokers following e-cigarette use.[149,150] However, when further analyses include other potentially mediating variables such as marijuana use and perceptions of smokers and smoking, the direct relationship between e-cigarette use and subsequent cigarette smoking is no longer evident.[151] In England, current use of e-cigarettes remains rare among never-smokers (including both adult and never smoking youth).[152]

The tobacco control field remains divided on this issue, with some advocating for a precautionary stance on e-cigarettes for smoking cessation while others argue that the concerns are disproportionate to the risks suggested by current evidence[151] and that by replacing tobacco cigarettes the devices could avert millions of deaths from smoking related disease.[153] Further longitudinal research and alternative quasi-experimental studies in this area is needed, and should take into account all appropriate confounders and report greater accuracy in the measurement and reporting of current e-cigarette use rather than combining measures of occasional and experimental use with that of more frequent daily and weekly use.

From a regulatory perspective, UK public health bodies have supported current smokers to switch to e-cigarettes as a safer form of nicotine delivery. This contrasts with the USA. Although e-cigarettes are acknowledged to be a safer alternative to smoking among adults, protecting non-smokers and adolescents from e-cigarette use is a primary concern.[154] This concern has arisen following a sharp increase in youth e-cigarette use in recent years[155], with 18% of 11-13 year old's reporting usage on 20-days in the past month.[156] This increase is strongly associated with lifetime tobacco use, but nonetheless diverges from trends among youth in the UK where weekly e-cigarette use among former smoking youth (age 11-18) is estimated to be 3.3% and <1% among never smokers.[131] Adding to these are concerns regarding a 2019 outbreak of lung disease that killed over 50 people in the USA. The outbreak, which was initially described as being linked to all e-cigarette devices, has now been specifically attributed to the presence of vitamin E acetate in e-cigarettes containing THC.[157] Despite confirmation from the Center for Disease Control and Prevention (CDC) that these unregulated products caused the outbreak, the initial reporting had included warnings against using any form of e-cigarette. Reporting of this nature has fuelled uncertainty among the public and likely led to a significant change in perceptions towards e-cigarettes as equally harmful or more harmful than smoking tobacco cigarettes, as highlighted by STS data in England.[158]

A deep-rooted concern regarding e-cigarettes is the tobacco industry's growing investment and support of e-cigarettes as a reduced harm alternative to tobacco smoking.[159] This concern may be valid given the industry's historical campaign of scientific distortion and misinformation, (well documented in the Tobacco Industry Documents, (www.industrydocumentslibrary.ucsf.edu/tobacco) to promote knowingly harmful and addictive products, and considering that the industry continues to market and sell cigarettes in countries with weaker regulation. Indeed, internal tobacco industry documents revealed plans to 'divide-and-conquer' the tobacco control movement by establishing relationships with researchers and advocates who held differences of opinion to the other members of the field with regard to modified risk products such as e-cigarettes.[160] However, thanks to their popularity, e-cigarettes may represent a paradigm shift in the tobacco control field from the precautionary principle towards harm minimisation thanks to the potential that the devices bring to adult smokers if used as a complete substitute for combustible tobacco.[161] Some argue that this will re-legitimise the industry by framing it with pharmaceutically aligned goals of 'modified-risk nicotine maintenance', allowing it to continue to sell products with unclear long-term risk.[162] However, if a the primary aim of tobacco control policy is to discourage smoking and provide methods by which they can quit successfully, e-cigarettes may play a role in facilitating this and prevent millions of people suffering from cigarette-induced mortality and morbidity.[163] To this end, further longitudinal data are necessary to further understand transitions between tobacco and e-cigarette use and the longer-term health effects of e-cigarettes.

1.6.6 E-cigarette use and socio-economic position

1.6.6.1 Differences in use across the socio-economic spectrum

A systematic review of differences in awareness and use between SEP groups from 35 different countries reported greater awareness of and 'ever use' of e-cigarettes among those with greater educational attainment.[164] In support of this finding, previous population estimates of e-cigarette use in Great Britain have indicated that the devices were used to a greater extent by advantaged SEP individuals during the period in which the devices first became popular.[165] Assuming that the devices are effective towards smoking cessation, and dependent on social patterning of e-cigarette use in successful quit attempts, differential use across the socio-economic spectrum has the potential to either increase or decrease existing inequalities in smoking cessation. Estimates of greater e-cigarette use by higher-SEP individuals broadly supports the theory of diffusion of innovations.[166] The theory states that the adoption of new technologies or innovations (in this case e-cigarettes) does not occur simultaneously in a social system and tends to be greatest among more advantaged socio-economic groups who have greater material and social capital and are thus more receptive to, or have greater access to, a given innovation. This potential negative equity impact is not unique to e-cigarettes but relates to other tobacco control interventions including behavioural support and pharmacotherapy, which also have the potential to increase inequalities in smoking cessation.[114]

1.6.6.2 Potential for smoking cessation in disadvantaged groups

Recent ethnographic research with 'working class' (disadvantaged-SEP) communities in northern England has highlighted the potential that e-cigarettes have to displace smoking in socio-economically disadvantaged groups. It was argued that upwardly socially mobile smokers may use e-cigarettes to resolve conflicts associated with their previous smoking behaviour, a behaviour that is now stigmatised among advantaged groups. In contrast, disadvantaged smokers indicated that they use the devices because they were pleasurable or because they felt a responsibility to be in good health for their family, and use did not specifically reflect a desire to simply quit smoking.[167] E-cigarettes may therefore present an opportunity to reduce inequalities in smoking cessation. There is also potential to provide e-cigarettes at homeless centres, considering that smoking rates in this group is almost four-times higher than in the general population.[168]

In the USA, National Health Interview Survey data have indicated that smokers with greater educational attainment were more likely to transition to exclusive e-cigarette use than less educated smokers.[169] This has been supported by further data from the Population Assessment of Tobacco and Health (PATH) study, also in the USA, which suggested that exclusive e-cigarette use was more likely among higher-income smokers.[170] Assuming a positive effect on smoking cessation, it is possible that e-cigarette use in the US context could therefore exacerbate the existing socio-economic inequalities in smoking cessation in the country.

1.7 Aims and research questions of the current thesis

Given a) the growing focus on Individual-level smoking cessation interventions for low-SEP smokers b) the limited evidence related to population-level rates of e-cigarette usage by SEP and c) the limited research into what lower SEP smokers think about e-cigarettes for smoking cessation the overall aim of this thesis was to use mixed-methods to assess the potential impact of e-cigarettes and individual-level interventions on existing inequalities in smoking cessation.

The thesis involved three distinct objectives. First, and in the context of the increasing number of programmes around the world that tailor individual-level interventions for disadvantaged smokers, a systematic review (Chapter 2) was conducted to examine whether SEP-tailoring improves smoking cessation compared with non-SEP-tailored approaches.

The second theme (Chapters 3 and 4) involved modelling population-level trends in e-cigarette usage by SEP using data from the STS. This is important given that e-cigarette devices are rapidly evolving with improved nicotine delivery and sensory experiences, and because potential differences across SEP groups need to be monitored to inform policies that act on health inequalities related to smoking cessation.

The final, qualitative theme (Chapters 5 and 6) involved interviews with disadvantaged participants and had two components: 1) To explore the motivations for and patterns of usage of an e-cigarette during a quit attempt, and 2) As part of the process evaluation of an ongoing RCT, to investigate acceptability of using the devices alongside clinical support and medication at stop-smoking services.

This thesis therefore seeks to answer the following research questions:

1) Does tailoring smoking cessation interventions for low-SEP smokers improve effectiveness compared with non-tailored approaches?
2) What are the population-level trends in e-cigarette use among important sub-groups of smokers and ex-smokers according to SEP?
3) What do lower SEP smokers think about the use of e-cigarettes in a quit attempt, and how are the devices used?

Chapter 2

Tailoring individual-level interventions for socio-economically disadvantaged smokers: A systematic review and meta-regression (Study 1)

Reference for publication (full paper in Appendix 1): Kock, L., Brown, J., Hiscock, R., Tattan-Birch, H., Smith, C., & Shahab, L. (2019) Individual-level behavioural smoking cessation interventions tailored for disadvantaged socio-economic position: a systematic review and meta-regression. *The Lancet Public Health, 4*(12), e628-e644

Abstract

Socio-economic inequalities in smoking cessation have led to development of interventions that are specifically tailored for smokers from disadvantaged groups (SEP-tailored interventions). This systematic review aimed to assess whether the effectiveness of interventions for disadvantaged groups is moderated by tailoring for socio-economic position (SEP). The secondary objectives were to explore the extent to which other study characteristics could explain anticipated heterogeneity in study estimates.

Several online databases including Medline, Psychinfo, Cochrane Central Register and Tobacco Addiction Register of Clinical Trials and the IC-SMOKE database were searched from their inception until August 18, 2019, for randomised controlled trials (RCTs) of socio-economic-position-tailored (SEP-tailored) or non-socio-economic-position-tailored (non-SEP-tailored) individual-level behavioural interventions for smoking cessation at 6 months or longer of follow-up in disadvantaged groups. Included studies operationalised SEP using measures of income-level, eligibility for government

financial assistance, occupation and housing status. Random-effects meta-analyses and mixed-effects meta-regression analyses were conducted to assess associations between tailoring of the intervention and intervention effectiveness. Meta-analysis outcomes were summarised as risk ratios (RRs, 95% CI). Characteristics of the intervention and the target population, method of randomisation, and completeness of follow-up were recorded. Biochemically validated or self-reported abstinence at 6 months follow-up in each trial was collected. Certainty of evidence of all included studies was assessed using the Cochrane 'Risk of bias 2' tool and the GRADE approach.

Forty-two RCTs (26,168 participants) were included. Of these RCTs, 26 interventions were SEP-tailored, 16 were non-SEP-tailored. All interventions (both SEP-tailored and non-SEP-tailored) were found to be effective for smoking cessation compared with control or usual care (RR 1.56, 95% CI 1.39-1.75, I^2=54.5%). SEP-tailored interventions did not yield better outcomes compared with non-SEP-tailored interventions for disadvantaged groups (adjusted RR = 1.01(logRR (*B*) = 0.01, SE = 0.11), 95% CI 0.81-1.27). Similar effect sizes were observed in separate meta-analyses of non-SEP-tailored interventions using trial data from participants with high SEP, although certainty of evidence from these studies was graded 'low'.

There was moderate certainty evidence that individual-level interventions can assist disadvantaged smokers to quit, but there were no large moderating effects of tailoring for disadvantaged smokers.

2.1 Background

As described in Chapter 1, tobacco smoking rates and the associated burden of mortality and disease[12] are greater among the socio-economically disadvantaged in most high-income countries.[46] These differences in smoking prevalence are evident for multiple measures of SEP including those related to material capital (income, housing tenure), human capital (education, occupation, neighbourhood deprivation) and social capital. In England, smoking rates are almost twice as high among those with manual occupations compared with more advantaged groups with professional to clerical occupation.[131] These results are supported by observations of smoking and SEP in other high income settings such as Australia[171] and the United States.[172] Individual smokers and their behaviour are central to population health related to smoking cessation.[58] Regular smoking is established and maintained by a variety of molecular and behavioural aspects linked to the rapid release of nicotine from cigarettes. Individual-level interventions play an important role in disrupting cigarette addiction[173] to support a successful quit attempt. However, even with the best support long-term quit rates remain low[56], especially among smokers from more disadvantaged groups.[111] Recognition that these smokers have greater difficulty in quitting and remaining abstinent than those from more affluent groups has led to the development of interventions that are specifically tailored for smokers from disadvantaged groups. There is growing consensus that health outcomes and inequalities are the result of multiple interdependent factors acting at the individual, community and population level in a complex system.[174] In addition to biological disease vectors and genetic differences, health outcomes in this context[175] are influenced by individual behavioural factors and social factors such as the social, cultural and political environment. Feedback loops exist between biological, individual and social components.

Thus, individual level interventions that recognise the wider context of socio-economically disadvantaged smokers may prove more successful.

2.1.1 SEP-tailored interventions

This chapter assesses the effectiveness of SEP-tailored and non-SEP-tailored individual-level behavioural interventions that aim to promote smoking cessation among individuals from socio-economically disadvantaged groups.

In this review, interventions were assessed according to whether they were SEP-tailored or not. SEP-tailored interventions are those developed specifically for individuals from socio-economically disadvantaged groups (termed 'low-SEP') and aim to overcome some of the specific barriers to quitting that smokers from these groups face compared with more affluent groups ('high-SEP'). These may include financial stress, lack of social support, addiction, lack of self-efficacy, stress and lack of life opportunities, and less interest in and understanding of tobacco harms (Table 1.2).[46] In contrast to SEP-tailored interventions, non-SEP-tailored interventions are not designed for disadvantaged groups specifically.[176] In some instances non-SEP-tailored interventions are delivered in a disadvantaged context/site to low-SEP recipients, but this targeting does not constitute 'SEP-tailoring' because the intervention has not been adapted or developed specifically for the recipients themselves. The two primary individual-level approaches to assist with smoking cessation are pharmacotherapy and behavioural support, and are often delivered in tandem.[106] Pharmacotherapies, such as NRT, varenicline and bupropion, aim to reduce the strength of urges to smoke and alleviate the unpleasant side effects associated with tobacco/nicotine withdrawal (Chapter 1).[108,177] Interventions solely involving pharmacotherapies were excluded from this review because the drugs themselves cannot be directly tailored for disadvantaged groups; it is the method of provision and advice around pharmacotherapy that can be adapted for more tobacco-dependent users.[113]

Behavioural support delivered using self-help materials, digitally, via-telephone or in person (see section 1.5.2.1) are categorised according to the modes of delivery or provider (e.g. stop smoking practitioner or clinician) of the support.[52] The use of incentives can also be delivered using these modes of support but differs in that it is a type of intervention function (as outlined in the Behaviour Change Wheel[178]).[61] A broad understanding of motivation suggests all behavioural interventions attempt to support motivation to resist urges to smoke and build individual capacity to adhere to their plans to avoid smoking. Tailoring interventions to participant characteristics can, in theory, enhance effectiveness of interventions by relating to the participant's life and needs and/or addressing specific obstacles to overcome in order to achieve a desired change.[82,179] SEP-tailored behavioural support may moderate effectiveness for smoking cessation because it addresses the barriers and enablers that disadvantaged users encounter by providing access to a form of social support, improving self-efficacy and improving understanding around the mechanisms and harms of tobacco use.

2.1.2 Previous reviews

Several Cochrane reviews have been published that focus on individual-level interventions that are not SEP-tailored, including methods such as motivational interviewing, behavioural support and different uses of pharmacotherapy.[61,63,106] Other reviews have assessed the equity effect of non-SEP-tailored interventions[57] or focused on interventions tailored towards disadvantaged smokers.[77,119] These reviews suggest that despite behavioural interventions showing promise for reducing inequalities, smoking cessation prevalence generally remains lower among disadvantaged groups.[180,181]

A review of research outputs concluded that current research was insufficient to encourage equity-positive improvements in smoking cessation.[182] In theory SEP-tailored individual-level approaches could play an important role in reducing health inequalities by relating to a participant's life and needs or overcoming specific obstacles to achieve a desired change.[183,114] To test this one must estimate whether tailoring moderates the effectiveness of interventions on smoking cessation in socio-economically disadvantaged groups. This is important considering the conclusions of previous reviews that some non-SEP-tailored interventions appear to have a negative equity impact on SEP inequalities due to greater success among smokers of high SEP.[114]

While previous reviews have focussed on the overall effect of individual-level interventions for smoking cessation in disadvantaged groups, to my knowledge, no previous reviews have directly assessed whether SEP-tailoring moderates the effectiveness of all types of individual-level interventions for smoking cessation in socio-economically disadvantaged groups. If it is apparent that SEP-tailored interventions are not clearly more effective than non-SEP-tailored interventions at increasing smoking cessation rates among disadvantaged smokers, then these approaches may need to be improved and adjusted in order to contribute to a reduction of health inequalities.

Therefore, the aim of this study was to assess whether the effectiveness of individual-level smoking cessation interventions for disadvantaged groups was moderated by SEP-tailoring. The review protocol was registered on the PROSPERO database of systematic reviews (ID CRD42018103008) and on the open science framework at https://osf.io/2z6cg/.

2.1.3 Objectives

This study had two research objectives:

1. To assess whether the effectiveness of individual-level smoking cessation interventions for disadvantaged groups is moderated by tailoring.
2. To explore the extent to which other study characteristics can explain anticipated heterogeneity in study estimates.

2.2 Methods

2.2.1 Types of studies

Conventional randomised controlled trials (RCTs) and pragmatic RCTs of SEP-tailored and non-SEP-tailored individual-level behavioural interventions for smoking cessation were included. Pragmatic RCTs are those that take place in routine clinical practice or in 'real-world' settings, and in theory better generalise to participants who would receive the treatment in future.[184]

2.2.2 Participants

Disadvantaged adult smokers, operationalised in terms of SEP (income, occupation/social grade, education, housing tenure, deprivation).

2.2.3 Interventions

Types of interventions

This review included trials of SEP-tailored smoking cessation interventions that were developed specifically for individuals from socio-economically disadvantaged groups, and RCTs of non-SEP-tailored smoking cessation interventions that take a 'gradient' approach (i.e. not aimed specifically at any SEP group).

Comparator interventions

Eligible comparator interventions were defined as those consisting of usual practice (as defined by the study author), no intervention or a placebo.

Excluded interventions

Interventions were excluded at the study screen stage if they were:

(a) Delivered at a community or population level, such as media campaigns, or policy, regulatory or legislative interventions.

(b) Did not examine or report differential effects by SEP.

(c) Provided pharmacotherapy with standard behavioural support compared with standard behavioural support.

(d) If smoking cessation outcomes were not reported from at least six months after the start of the intervention, in line with previous Cochrane reviews.[61]

2.3 Outcome measures

Primary outcomes

The primary outcome for my analysis was abstinence from smoking after at least 6 months of follow-up, which is a standard long-term outcome measure for smoking cessation trials used in Cochrane reviews. Biochemically validated measures of abstinence were used where possible (exhaled carbon monoxide (CO), saliva/plasma/urinary cotinine levels). Self-reported abstinence as a measure of smoking cessation was included if a study did not perform biochemical validation.

Intervention type and intensity

The type of behavioural support (i.e. mode of support) was collected in order to segment analyses according to intervention type. The intensity of support (number of sessions and the professional background of the person delivering the intervention) was measured as a potential confounder, considering that SEP-tailored interventions likely involved some form of augmented delivery. For instance, SEP-tailored programmes might include more intervention sessions/components or be delivered by different professionals with varying experience. Other study covariates that I collected included whether participants in the intervention arm of the trial received pharmacotherapy, whether the control arm of the trial was active (i.e. received some form of intervention or usual care), whether the study was deemed to have some concerns or high risk of bias, whether cessation was biochemically validated, and whether participants had stated an intention to quit smoking. I extracted outcomes from SEP-tailored and non-SEP-tailored interventions. For non-SEP-tailored interventions, outcomes for disadvantaged individuals were extracted from studies that report smoking cessation outcomes by SEP.

Search methods

This systematic review and meta-regression followed PRISMA guidelines. The following electronic databases were searched from their inception:

- Medline
- PsychInfo
- Embase
- Cochrane Central Register of Clinical Trials (CENTRAL)
- Cochrane Tobacco Addiction Specialised Register of Trials
- IC-SMOKE database[73]

Searching other resources

- Clinical trials (https://clinicaltrials.gov)
- International clinical trials registry (https://who.int/ictrp/en/)
- Trials Register for Promoting Health Interventions (https://eppi.ioe.ac.uk/webdatabases/Search.aspx)

Search terms for electronic databases

Smoking cessation interventions: smoking cessation or smok* quit* or smok* stop* or smok* cease or smok* cessat* or smok* give up (title and abstract)

RCT design: RCT or randomi?ed controlled trial or trial or randomi?ed or controlled clinical trial or pragmatic clinical trial (title and abstract)

Individual-level behavioural support: behavio* or behavio?ral support or intervention or counsel* or brief or support or psychol* or individual* or individual-level or behavio?r therapy or cognitive therapy or target* or adapt* or tailor*) not pharma* (title and abstract)

Socio-economic position: equity or equity impact or inequalit* or under-served or under served or underserved or marginali?ed or poor or affluent or disparit* or SES or socio-economic or socio-economic or depriv*OR disadvant* social class or occupation or employ or unemploy* or educat* or income or poverty or neighbo?r* (multiple searches) The study protocol is available on the open science framework online at https://osf.io/2z6cg/.

2.4 Data collection and analysis

Selection of studies

I obtained references using the aforementioned search methods and stored the studies in Covidence (www.covidence.org) reference management software, where all duplicate studies were removed. Papers were screened according to the title and abstract (where available), using specific inclusion and exclusion criteria. Charlie Smith (CS, a PhD student at UCL) and I independently screened all abstracts. I screened all full-text articles and CS screened 10% of full-text articles. Inter-rater reliability at abstract screening (Cohen's k=0·81) and full study screening (Cohen's k=0·78) were high (Appendix 4). I extracted all study data myself. To check reliability, 10% of data extraction was done independently by Harry Tattan-Birch (HTB, a PhD student at UCL). Percentage agreement was more than 98% after comparison (Appendix 4). Any conflicts that surfaced over inclusion and data extraction were resolved through discussion. HTB and I independently assessed the risk of bias and certainty of evidence using the Cochrane risk-of-bias tool version 2 and the GRADE approach.[185]

Data extraction and management

Duplicate papers reporting data from the same trial were identified and the secondary papers were excluded before data extraction. A customised data extraction form (available online at https://osf.io/2z6cg/) was used to extract data from studies that met the eligibility criteria. The following information was extracted:

Methods: country/setting of trial, design, objectives, study site, methods of analysis.

Participants: age, gender, ethnicity, SEP, n-values for eligibility, recruitment and completion.

Interventions: descriptions of interventions and controls, duration, intervention delivery, type/dose/duration of pharmacotherapy or behavioural support, and control group components.

Outcomes: Outcome data as defined in section 2.3, method of outcome collection and validation (self-reported or biochemically verified), pre-specified outcome data, follow-up period, other measures of abstinence/reduction.

Measurement of treatment effect and data synthesis

For trials of both SEP-tailored and non-SEP-tailored interventions, I extracted binary data on smoking cessation outcomes (i.e. abstinence or continued to smoke in the intervention and control groups) to calculate risk ratios (RRs) and 95% confidence intervals (CIs). If counts of the intervention outcomes were given without RRs then I calculated these manually in the data extraction form. The analysis followed an intention-to-treat (ITT) protocol whereby participants lost to follow-up were classified as 'continued to smoke'.

I used the restricted maximum-likelihood estimator method to estimate a pooled risk ratio with a 95% CI.

Assessment of heterogeneity

The field of smoking cessation is characterised by diverse interventions, settings and participants. I therefore deemed it likely that studies would display heterogeneity in treatment effect (the observed intervention effects being more different from each other than expected due to random error). The assumptions of a fixed effect meta-analysis (that all studies in the meta-analysis share a common overall effect size and that all factors that could influence the effect size are the same across studies), were therefore unlikely to hold.

Each included study in this review provided information about a different effect size for smoking cessation. In a random-effects model the aim is to estimate the mean of a distribution of effects without being overly influenced by any individual study.[186] Therefore, each study is weighted by the inverse of both its within- and between-study variance (Appendix 4). The standard error of the summary effect is calculated as the square-root of this variance.

In random effects meta-analysis models (restricted maximum-likelihood method[187]) used in this review, I calculated pooled RRs with 95% confidence intervals for both SEP-tailored and non-SEP-tailored interventions as the weighted average of each individual study's estimated intervention effect. All computations were conducted on a log scale using the log risk ratio, its variance, and standard error, before exponentiating the summary effect for interpretation.

I explored heterogeneity through observation of forest plots and use of the Chi^2 test to assess whether observed differences in results were compatible with chance alone. I^2

statistics were calculated to examine the level of inconsistency across study findings.[186] Values of I^2 reflect the degree of overlap of confidence intervals, with lower values indicating that observed variance is spurious and higher values suggesting that there are real differences in effect size between studies.

The following comparisons were explored using meta-analysis forest plots:

- Individual-level interventions (SEP-tailored and non-SEP-tailored) versus passive or active control/usual care
- SEP-tailored individual-level interventions versus passive or active control/usual care
- Non-SEP-tailored individual-level interventions (subgroups of low-SEP and high-SEP participants) versus passive or active control/usual care.

A conventional meta-analysis combines results from studies to estimate a single summary effect size. However, diversity in populations and methods among studies included in a meta-analysis often leads to statistical heterogeneity in the true effects of these studies. Meta-regression extends subgroup analyses and allows, in principle, the effects of multiple factors to be investigated simultaneously. Therefore, in contrast to a meta-analysis, meta-regression aims to relate the size of effect to one or more factors or characteristics of the studies involved. In meta-regression, a pooled effect estimate is predicted based on values of one or more of these explanatory study-level variables that might influence the size of the intervention effect.[188] Given sufficient numbers of trials (ten studies for each covariate has been considered to be sufficient[188]), unadjusted and adjusted mixed effects meta-regression analyses were used to assess whether variation among studies in smoking cessation effect size was moderated by tailoring of the intervention for disadvantaged groups. The regression coefficient obtained indicates how the outcome variable (log risk ratio for smoking cessation) changes when interventions take a SEP-tailored vs non-SEP-tailored approach. A statistically significant ($p<.05$) coefficient suggests that there is a linear relationship between the effect estimate for smoking cessation and the explanatory variable. It is also possible to include more moderators (study-level variables) in the model that may account for part of the heterogeneity in the true effects.

An adjusted model was pre-registered on the open science framework (https://osf.io/2z6cg/) to include important study covariates related to the intensity and delivery of the intervention (number of sessions delivered (above median vs below median), whether interventions were delivered by a specialist trained in smoking cessation (SCS; yes vs no), and use of any form of pharmacotherapy (see section 1.5.2.2) in the intervention arm (yes vs no). These covariates were included a priori as potential confounders given that SEP-tailored programmes may include more intensive interventions involving multiple sessions/components or be delivered by different professionals with varying experience. The regression coefficient estimates how the intervention effect in the SEP-tailored sub-group differs from the reference group of non-SEP-tailored interventions. The true effect for smoking cessation θi in the adjusted meta-regression is given by

$$\theta i = \beta_0 + \beta_1 \mathit{SEP\text{-}tailored}_i + \beta_2 \mathit{SCSi} + \beta_3 \mathit{Pharmacotherapy}_i + \beta_4 \mathit{NumberSessions}_i + \varepsilon_k + \xi_k$$

where ε_k is the sampling error through which the effect size of the study deviates from the 'true' effect and ξ_k indicates that the true effect size of the study is sampled from an overall distribution of effect sizes.

Briefly, in frequentist statistics, non-significant effects or associations, typically those above the threshold *P* value of 0.05, are often interpreted as evidence for the null hypothesis (that there is no effect or association). *P* values are an appropriate method to understand how likely a result is given a particular null hypothesis, but it is important to consider that they are calculated with the assumption of the null hypothesis meaning there is exactly no effect, which is highly improbable outcome in an experimental or observational setting.[189] In reality, a non-significant association can either mean that there is evidence for the null hypothesis (there is evidence against a theory that predicted a difference or a relationship), or that the data are insensitive to detect an effect, and conclusions cannot be drawn from the data. In contrast to the frequentist approach, Bayesian theory commences with a belief about the quantity of interest that a researcher is looking to estimate (the prior, which can be informed by previous research or rational deduction), before observing the data that have been collected to update or revise the belief in response to it. By indicating the relative strength of two theories, in this instance comparing the alternative hypothesis with the null hypothesis, the calculation of Bayes factors (BFs) allow researchers to make stronger inferences as to whether a non-significant association represents evidence for the null hypothesis (that there is no treatment effect), or else that the data collected are insensitive to detect an effect.[190] Therefore, in the analysis of data from this current meta-regression, where a non-significant ($p<.05$) association between SEP-tailoring and intervention effectiveness was estimated, I carried out sensitivity analyses using BFs to allow greater inference and better examination of whether the association reflected evidence of no effect, evidence of an effect, or whether the data were insensitive to detect an effect.[191,190]

There is limited literature comparing the effectiveness of SEP-tailored versus non-SEP-tailored interventions for smoking cessation. A previous meta-analysis assessing whether interventions for low-income groups were effective for smoking cessation estimated a small positive effect (RR = 1.59).[192] Therefore, with the assumption that SEP-tailoring is equity positive (i.e. improve quit success among low-SEP smokers to a greater extent than if they had received a non SEP-tailored intervention), alternative hypotheses were set using half-normal distributions with a maximum expected effect size set to RR = 1.5. To test sensitivity to detect small positive effects of SEP-tailoring, a BF was also calculated using an expected effect size of 1.1. A BF of <1/3 can be interpreted as evidence for the null hypothesis (SEP-tailoring does not moderate effectiveness), while a BF of >3 can be interpreted as good evidence for the alternative hypothesis (SEP-tailoring does moderate effectiveness). A BF between 1/3 and 3 suggest that the date are insensitive to detect an effect, and that more data is needed.[190]

To explore the extent to which other study-level variables could explain anticipated heterogeneity in the study estimates, further exploratory unadjusted univariate and adjusted models were conducted. I also conducted subgroup analyses for the comparison between subgroups of low-SEP and high-SEP participants in non-SEP-tailored individual-level interventions. To test whether the estimates in each sub-group are different from each other, I fitted two separate random-effects models within each subset (low SEP and high SEP) defined by the SEP variable. The SEP variable indicated whether the sample for analysis was ‘low’ or ‘high’ SEP. I then combined the estimates and standard errors from each model into a data frame. A variable was added to distinguish the two models and for reasons explained below, I added the estimated amounts of heterogeneity within each subset to the data frame. To compare the two estimates (average log risk-ratios), they were fed back into a meta-analysis model using the model variable to distinguish the two estimates as a moderator (highSEP vs lowSEP). A fixed effect model was used because the residual heterogeneity within each respective subset had already been accounted for by fitting the random-effects models outlined above.

All analyses were conducted in the RStudio development environment (v1.1.463) using R version 3.5.2 and the package 'metafor'.[193,194] I calculated Bayes factors using an online calculator at http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/Bayes.htm.

Assessment of risk of bias in included studies

Using the Cochrane 'risk of bias 2' tool[195], risk of bias for each study was assessed during the randomisation process, due to deviations from intended interventions, due to missing outcome data, due to bias in measurement of the outcome or in selection of the reported result.

Publication bias was assessed using funnel plots. If after visual inspection, there was some evidence of funnel plot asymmetry, Egger's regression test was conducted to assess this.[196] Egger's test (in this instance using a random-effects model) involves regressing the standard normal deviate (the RR divided by its standard error) against the estimate's precision (the inverse of the standard error). If there is a relationship between the outcomes and the predictor (standard error), then it suggests that there is asymmetry in the funnel plot, which may reflect publication bias. This is problematic if studies of interventions with ’null’ (non-significant estimates of study effect) findings were less likely to be published. If this were the case, then it may lead to inaccurate conclusions of intervention effect based on the pooled estimates of published findings.

Unit of analysis issues

Where studies involved more than two trial arms, intervention arms were combined to create a single pair-wise comparison in accordance with Cochrane guidelines.[197]

Dealing with missing data

Studies in which insufficient data were available (either from the published report or after contacting the authors) were excluded from the review.

Certainty of evidence

The certainty of evidence of each included study was assessed using the Cochrane risk of bias 2 tool[195] and the GRADE approach[185] (see Appendix 4).

2.5 Results

Description of studies

From a total of 2,376 identified studies, full text articles of 348 were shortlisted for screening. Of these, 42 studies (26,168 participants) were included in this review (Figure 2.1, Table 2.1). Of included studies, n = 26 were trials of SEP-tailored interventions, while n = 16 were non-SEP-tailored interventions. The measures of SEP used by studies when classifying their sample were varied (Table 2.1)

Study populations

Of the 26 SEP-tailored intervention studies included in this review (Figure 2.1, Table 2.1a and 2.1b), n = 17 were delivered in-person or via telephone, n = 4 were digital interventions, n = 3 involved financial incentives and n = 2 were brief interventions. Of the 16 non-SEP tailored interventions n = 6 were delivered in-person, n = 5 were delivered digitally, n = 2 involved financial incentives and n = 3 were brief interventions.

Thirty of the 42 studies were conducted in the USA. Three studies were conducted in the UK, two each in the Netherlands and Australia and one each in Switzerland, Sweden, Turkey, India and China.

Ten studies recruited participants at hospitals/clinics during a 'health triggering' event.[198, 199, 200, 201, 202, 203, 204, 205, 206, 207] A health triggering event included anything that warranted a visit to a hospital or clinic such as heart disease[200], dental health[199, 201], primary care visits[203], planned parenthood visits[202], and child health[196, 198, 204, 205]. Nine studies recruited only women.[198, 203, 205, 207, 208, 209, 210, 211, 212] Three studies involved pregnant women exclusively[207,208,212] and one study recruited only men whose partners were pregnant.[206] White participants were the majority in 23 studies, while African American participants were the majority in 12 studies.[199, 198, 200, 204, 211, 213, 214, 215, 216, 217, 218, 219] One study recruited only Chinese participants, and another only Indian participants.[220,221]

Intervention type

The behavioural interventions included in this review varied according to the mode of delivery (support delivered face to face, by telephone or using digital means), provider of support (in the case of brief interventions delivered by healthcare professionals), or intervention function (the use of financial incentives). In-person/telephone support typically included one or more sessions with a professional who assisted in the quit attempt. These professionals included clinicians, nurses or health educators either providing smoking cessation support as part of their post or working as a smoking cessation specialist. Digital behavioural support involved interactive and tailored smoking cessation support delivered via text messages, on a website or page accessible on a computer or other device. Financial incentive condition participants received incentives conditional upon attending support sessions or health visits and/or contingent upon biochemically validated smoking abstinence at follow-up. Brief interventions consisted of brief advice and assistance related to smoking cessation and outlined general health risks from smoking.

Studies with active and passive controls

Twenty-one studies in this review had 'active' control groups. Active controls are those that received some form of intervention albeit at lower intensity compared with the main intervention condition. These included small financial incentives for attending follow-up sessions[212], telephone support[201,222] or encouragement to use a quit-line[218], baseline[203,217] or repeated face-to-face support sessions[219,223], and the offer of or access to pharmacotherapy.[200,222,224, 223] Detailed supplementary tables regarding data extraction, trial description and participant demographics for each study can be found online on the open science framework https://osf.io/2z6cg/.

Figure 2.1: PRISMA flow diagram of study selection process

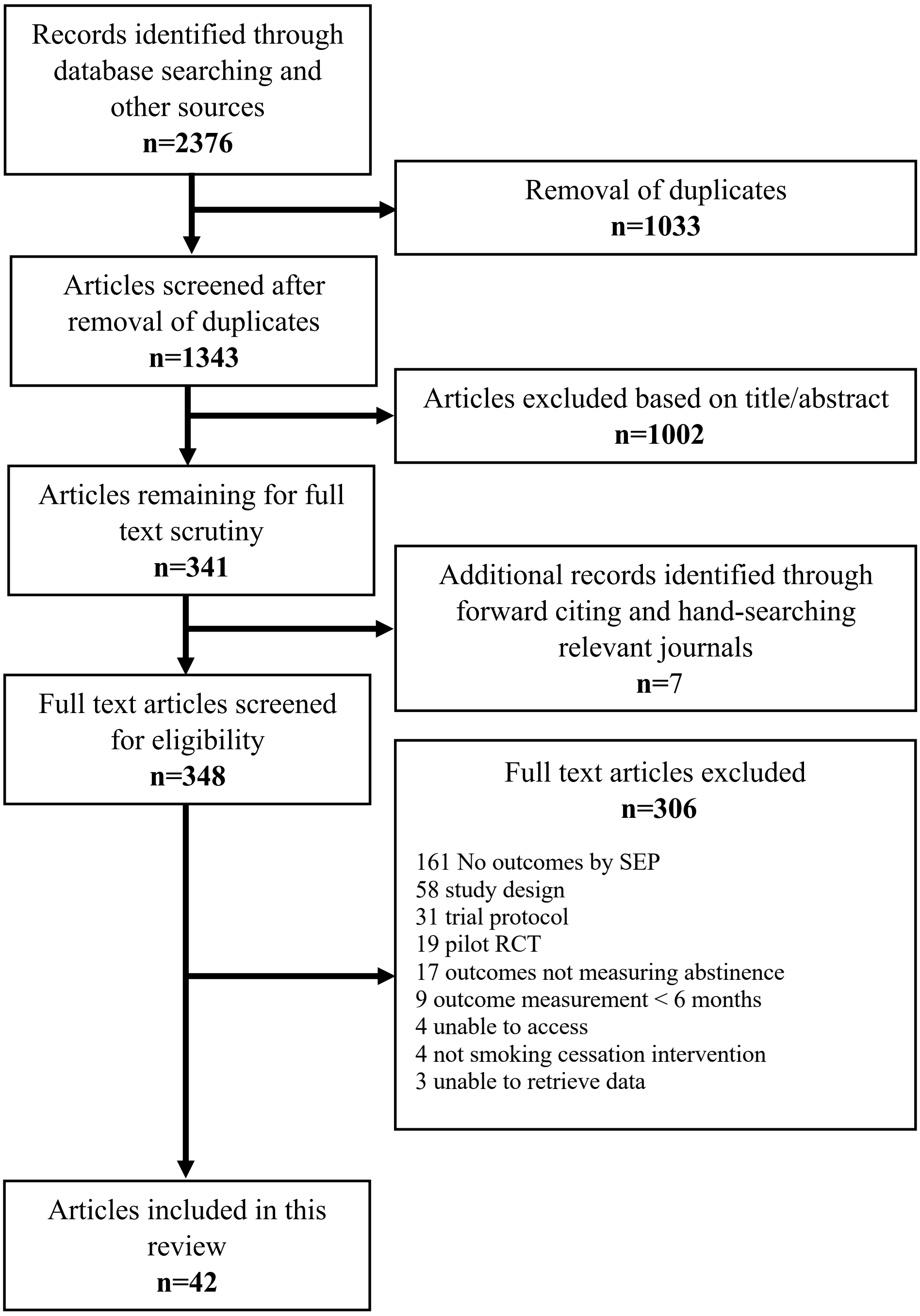


Table 2.1a: Characteristics of studies

	Country	Study design	SEP-tailoring?	Sample SEP	% Women	Mean age	No. randomised	Intention to quit	Cigarettes/day (mean, 95% CI)
Abroms, 2014[225]	USA	2 arm RCT	No	21.9% high school or lower	66	38	503	No	17.3 (13.9-20.7)
Andrews, 2016[209]	USA	2 arm RCT	Yes	79.4% <$20,000/year	100	42	200	Yes	12.7 (7.9-17.6)
Baker, 2018[210]	USA	2 arm RCT	No	Medicaid registered	100	26	1014	Yes	Not reported
Berndt, 2018[199]	Netherlands	3 arm RCT	No	41.8% primary and basic vocational	46	56	625	No	21.1 (17.8-24.4)
Bonevski, 2018[226]	Australia	2 arm pragmatic RCT	Yes	94% on state benefits	49	38	431	No	15 (11.5-18.5)
Brooks, 2017[217]	USA	2 arm cluster-randomised trial	Yes	Public housing resident	74	Not reported	331	Yes	Not reported
Brown, 2014[118]	UK	2 arm RCT	Yes	46.4% long-term unemployed/routine and manual occupation	63	39	4613	Yes	18.6 (17.5-19.7)
Choi, 2014[220]	USA	2 arm RCT	Yes	61.1% high school or less	20	42	145	No	21.0 (14.0-28.0)

Curry, 2003[196]	USA	2 arm RCT	Yes	43.2% <$10,000/year	100	34	303	No	12.1 (8.26-15.9)
Davis, 2014[222]	USA	2 arm RCT	Yes	49.5% high school or less	50	42	196	Yes	Not reported
Danan, 2018[227]	USA	2 arm RCT	No	49.5% high school or less	5	60	2430	No	≤10 = 36%, 11-20 = 42%, ≥21 = 22%
Etter, 2016[228]	Switzerland	2 arm RCT	No	18% unemployed	50	32	805	Yes	16.0 (13.4-18.6)
Fraser, 2017[216]	USA	2 arm RCT	Yes	Medicaid registered	61	45	1900	No	17.2 (15.5-18.9)
Free, 2011[229]	UK	2 arm RCT	No	31% manual occupation	45	37	5800	Yes	Not reported
Froelicher, 2010[217]	USA	2 arm RCT	Yes	58.3% <$15,000/year	73	47	60	No	11.3 (2.5-20.1)
Fu, 2016[221]	USA	2 arm RCT	Yes	Medicaid registered	71	Not reported	2406	No	13.6 (12.2-15.0)
Glasgow, 2000[201]	USA	2 arm RCT	No	42.7% high school or less	100	24	1154	No	12.0 (10.1-13.9)
Gordon, 2010[198]	USA	2 arm RCT	Yes	At or below 200% of US federal poverty level	58	41	2637	No	Not reported
Haas, 2015[230]	USA	2 arm RCT	Yes	62.3% Medicaid or Medicare recipient	69	50	707	No	15.0 (12.3-17.7)

Karacan, 2006[203]	Turkey	3 arm RCT	No	50.5% <$250/month	100	Not reported	363	No	6.30 (3.67-8.94)
Kendzor, 2012[214]	USA	2 arm RCT	No	61.1% unemployed	52	42	379	No	Not reported
Lasser, 2017[202]	USA	2 arm RCT	No	55% <$20,000/yea r	54	50	352	Yes	15 (11.1-18.9)
Lepore, 2018[197]	USA	2 arm RCT	Yes	78.7% income below poverty level	84	33	327	No	11.5 (7.85-15.1)
Lou, 2013[202]	China	2 arm RCT	No	Mean income $3015/year	52	Not reported	3562	No	Not reported
Marks, 2002[231]	UK	2 arm RCT	No	37% unemployed	Not reporte d	Not reported	260	No	Not reported
McClure, 2018[232]	USA	2 arm RCT	Yes	62.6% <$20,000/yea r	62	44	718	No	19.1 (16.2-22.0)
Mundt, 2019[212]	USA	2 arm RCT	Yes	Medicaid registered	60	45	1900	No	17.2 (15.5-18.9)
Nohlert, 2009[200]	Sweden	2 arm RCT	No	23% 0-9 years education	80	Not reported	300	No	Not reported as mean
Okuyemi, 2007[213]	USA	2 arm cluster-randomise d trial	No	Public housing resident	72	46	174	No	17.5 (11.6-23.4)

Pbert, 2004[205]	USA	2 arm cluster-randomised trial	Yes	46.7% less than high school	100	26	609	No	16.7 (13.6-19.7)
Prokhorov, 2008[233]	USA	2 arm RCT	Yes	Community college students	59	23	426	No	12.5 (9.2-15.7)
Rash, 2018[234]	USA	2 arm RCT	Yes	Homeless	26	45	70	Yes	15.4 (6.2-24.6)
Ruger, 2008[206]	USA	2 arm RCT	Yes	Medicaid registered	100	26	302	No	Not reported
Sarkar, 2017[218]	India	2 arm cluster-randomised trial	Yes	75.9% <$70/month	20	46	1213	No	Not reported
Sheffer, 2017[235]	USA	2 arm RCT	Yes	56.8% <$10,000/year	19	48	256	Yes	13.8 (9.4-18.2)
Solomon, 2005[210]	USA	2 arm RCT	Yes	Medicaid registered	100	34	330	Yes	23.6 (18.9-28.3)
Solomon, 2000[209]	USA	2 arm RCT	Yes	Medicaid registered	100	33	214	Yes	23.7 (17.7-30.0)
Sorensen, 2007[236]	USA	2 arm RCT	Yes	Routine and manual occupation	6	41	674	No	Not reported
Stanczyk, 2016[237]	Netherlands	3 arm RCT	No	33.6% 'low' education	62	45	2099	Yes	18.9 (17.2-20.6)

Stanton, 2004[204]	Australia	2 arm RCT	Yes	Undefined 'lower' SEP (Public hospital setting)	0	Not reported	561	No	Not reported
Strecher, 2008[238]	USA	2 arm RCT	No	36.2% high school or less	60	Not reported	1866	Yes	Not reported
Vidrine, 2018[211]	USA	3 arm RCT	No	70% high school or less	51	49	624	Yes	≤10 = 30%, 11-20 = 46%, ≥21 = 24%

Table 2.1b: Characteristics of studies continued

	Intervention condition	Control condition	Pharmacotherapy	Outcome	Follow-up	Biochemical verification	SEP measure
Abroms, 2014[225]	Text message smoking cessation program	Link to Smokefree.gov website	None	30-day point prevalence	6 months	Yes	Education
Andrews, 2016[209]	Face to face individual and group support plus NRT	Written materials	NRT	7-day point prevalence	6 months	Yes	Income
Baker, 2018[210]	High financial incentive plus counselling	Low financial incentive plus counselling	None	7-day point prevalence	6 months post-birth	Yes	Welfare status
Berndt, 2018[199]	Telephone and face to face counselling	Usual care	NRT	12-month continued abstinence	12 months	Yes	Education
Bonevski, 2018[226]	Brief advice and motivational interviewing	On-screen advice to quit, quitline number	NRT	6-month continued abstinence	6 months	Yes	Welfare status
Brooks, 2017[217]	Motivational interviewing plus NRT offer	Written materials plus brief advice, NRT offer	NRT offered	7-day and 30-day point prevalence	12 months	Yes	Housing tenure
Brown, 2014[118]	An interactive website intervention	Static website with brief advice	None	6-month continued abstinence	6 months	Yes	Occupation
Choi, 2014[220]	Website plus telephone support and NRT	Telephone support and NRT	NRT	7-day point prevalence	6 months	Yes	Education

Curry, 2003[196]	Motivational interviewing plus telephone support	Usual care	None	7-day point prevalence	12 months	No	Income
Davis, 2014[222]	Mindfulness training plus NRT	Telephone support plus NRT	NRT	7-day point prevalence	6 months	Yes	Education
Danan, 2018[227]	Proactive outreach with offer of telephone counselling or referral to in-person.	Usual care	NRT, Buproprion or Varenicline available	6-month continued abstinence	6 months	No	Education
Etter, 2016[228]	Written materials, website access and escalating financial rewards	Written materials plus website access	None	12-month continued abstinence	6 months	Yes	Occupation
Fraser, 2017[216]	Telephone support plus extra financial incentive	Telephone support plus financial incentive	None	7-day point prevalence	6 months	Yes	Welfare status
Free, 2011[229]	Text messaging smoking cessation programme	Text messages unrelated to quitting	None	6-month continued abstinence	6 months	Yes	Occupation
Froelicher, 2010[217]	Face to face support plus industry and media messaging	Face to face support	Unclear	7-day point prevalence	6 months	Yes	Income
Fu, 2016[221]	Usual care plus proactive telephone and written outreach and NRT	Usual care	NRT	12-month continued abstinence	12 months	No	Welfare status

Glasgow, 2000[201]	Brief behavioural support and clinician advice	Written materials and advice	None	30-day point prevalence	6 months	Yes	Income
Gordon, 2010[198]	Brief advice and assistance and NRT	Usual care	NRT	6-month continued abstinence	7.5 months	No	Income
Haas, 2015[230]	Telephone support plus NRT	Usual care	NRT	7-day point prevalence	9 months	No	Welfare status
Karacan, 2006[203]	General health information, child and mother health risks and booklet	General health information	None	7-day point prevalence	6 months	No	Income
Kendzor, 2012[214]	Standard care plus intervention delivered using palmtop computer	Self-help materials plus counselling and NRT	NRT	30-day point prevalence	6 months	Yes	Employment
Lasser, 2017[202]	Enhanced usual care (Face to face support plus written materials and information on local cessation resources)	Usual care (face to face support)	NRT offered	7-day point prevalence	12 months	Yes	Income
Lepore, 2018[197]	Face to face and telephone support	Nutrition intervention	None	7-day point prevalence	12 months	Yes	Income
Lou, 2013[202]	GP face to face support	Usual care	None	6-month continued abstinence	30 months	Yes	Income
Marks, 2002[231]	Enhanced written materials package	Written materials	None	7-day point prevalence	12 months	Yes	Income
McClure, 2018[232]	Telephone support, written materials	Telephone support plus written materials	NRT offered	7-day point prevalence	12 months	No	Income

	and oral health intervention						
Mundt, 2019[212]	Financial incentive for taking offered counselling calls	Offer of counselling calls	Offered	7-day point prevalence	6 months	Yes	Welfare status
Nohlert, 2009[200]	Multiple face to face support sessions	One face to face support session and written materials	None	7-day point prevalence	12 months	No	Education
Okuyemi, 2007[213]	Face to face and written materials addressing smoking cessation plus NRT	Face to face and written materials addressing nutrition	NRT	7-day point prevalence	6 months	Yes	Housing tenure
Pbert, 2004[205]	Face to face support and written materials	Usual care	None	7-day point prevalence	6 months post-birth	Yes	Income
Prokhorov, 2008[233]	Computer-assisted support and motivational interviewing	Brief face to face support and written materials	None	7-day point prevalence	10 months	Yes	Income
Rash, 2018[234]	Standard care plus financial incentives	Face to face counselling	NRT	7-day point prevalence	6 months	Yes	Housing tenure
Ruger, 2008[206]	Motivational interviewing and relapse prevention support	Usual care	None	30-day point prevalence	6 months post-birth	Yes	Welfare status
Sarkar, 2017[218]	Brief face to face support and breathing exercises	Very brief advice	None	6-month continued abstinence	7 months	Yes	Income
Sheffer, 2017[235]	Enhanced standard care: SEP-tailored face to face	Face to face cognitive behavioural	NRT	7-day point prevalence	6 months	Yes	SEP (income and education)

	cognitive behavioural treatment for tobacco dependence, NRT	treatment for tobacco dependence, NRT					
Solomon, 2005[210]	Proactive telephone support plus pharmacotherapy	Pharmacotherapy	NRT	7-day and 30-day point prevalence	6 months	No	Welfare status
Solomon, 2000[209]	Proactive telephone support plus pharmacotherapy	Pharmacotherapy	NRT	7-day point prevalence	6 months	Yes	Welfare status
Sorensen, 2007[236]	Telephone delivered motivational interviewing, tailored written materials and NRT	Written materials	NRT offered	7-day point prevalence	6 months	No	Occupation
Stanczyk, 2016[237]	Text and internet based intervention	General advice	None	12-month continued abstinence	12 months	Yes	Education
Stanton, 2004[204]	Smoking cessation video plus NRT	Written materials	NRT	NR	6 months	Yes	Education/occupation
Strecher, 2008[238]	High-depth website intervention plus NRT	Low-depth website intervention plus NRT	NRT	7-day point prevalence	6 months	No	Education
Vidrine, 2018[211]	NRT plus text and phone calls	NRT alone	NRT	30-day point prevalence	6 months	Yes	Education

Risk of bias of included studies

Figure 2.2 provides details about risk of bias of included studies. thirty studies reported the randomisation process in sufficient detail to be classified as having low risk of bias. In most other trials, the method of allocation concealment was not well reported. Seven studies were judged to be at high risk of bias due to potential deviations from the intended interventions in the trial. Examples of this include poor participation in or adherence to intervention components (such as behavioural support sessions or use of digital intervention and use of pharmacotherapy). Studies that reported biochemically validated abstinence were judged to be at low risk of bias for measurement of the outcome. Eight studies where abstinence was self-reported and not validated biochemically were judged to be at high risk of bias. The risk of bias from missing outcome data was judged to be low if loss to follow-up was low and similar across arms in the trial. Five studies were judged to be at high risk of bias due to high dropout and/or unequal follow-up between different trial arms. Most studies were judged to be at low risk of bias in selective reporting of results due to adherence to trial protocols and pre-specified sample power calculations. Overall, six of the 42 included studies (14%) were classified as being at low risk of bias on all domains considered in the assessment.[193] Risk of bias assessment was conducted independently by two reviewers who came to agreement about the final assessment of risk of bias for each study. Risk of bias assessment tables are available at https://osf.io/2z6cg/.

Excluded studies

Approximately half (n=161) of potentially relevant studies were excluded during full text review because they did not report smoking cessation outcomes by SEP. Other reasons for exclusion at this stage can be seen in the PRISMA diagram (Figure 2.1) and were due to studies not fulfilling the pre-specified inclusion criteria related to study design, outcome reporting and measurement, and being unable to access the papers or retrieve data from the study authors.

Figure 2.2: Methodological quality summary and risk of bias assessment

Study	The randomization process	Deviations from the intended interventions (effect of assignment to intervention)	Deviations from the intended interventions (effect of adhering to intervention)	Missing outcome data	Risk of bias in measurement of the outcome	Selection of the reported result	Overall judgement
Abroms 2014	+	+	+	+	+	+	+
Andrews 2016	+	+	+	+	+	+	+
Baker 2018	+	+	?	?	?	?	?
Berndt 2018	+	?	?	?	?	+	?
Bonevski 2018	?	+	-	+	+	+	-
Brooks 2017	?	-	-	?	+	?	-
Brown 2014	+	+	+	+	+	+	+
Choi 2014	?	+	-	-	-	+	-
Curry 2003	+	?	?	+	+	?	?
Davis 2014	?	?	-	-	+	+	-
Danan 2018	+	+	?	?	-	+	-
Etter 2016	+	+	+	?	+	+	?
Fraser 2017	+	+	?	+	?	?	?
Free 2011	+	+	+	+	+	+	+
Froelicher 2010	+	?	-	-	+	-	-
Fu 2016	+	?	?	?	-	+	-
Glasgow 2000	+	+	?	?	+	+	?
Gordon 2010	?	?	?	-	-	+	-
Haas 2015	?	+	?	+	-	+	-

*Low risk of bias = "+"; some concerns = "?"; high risk of bias = "-"

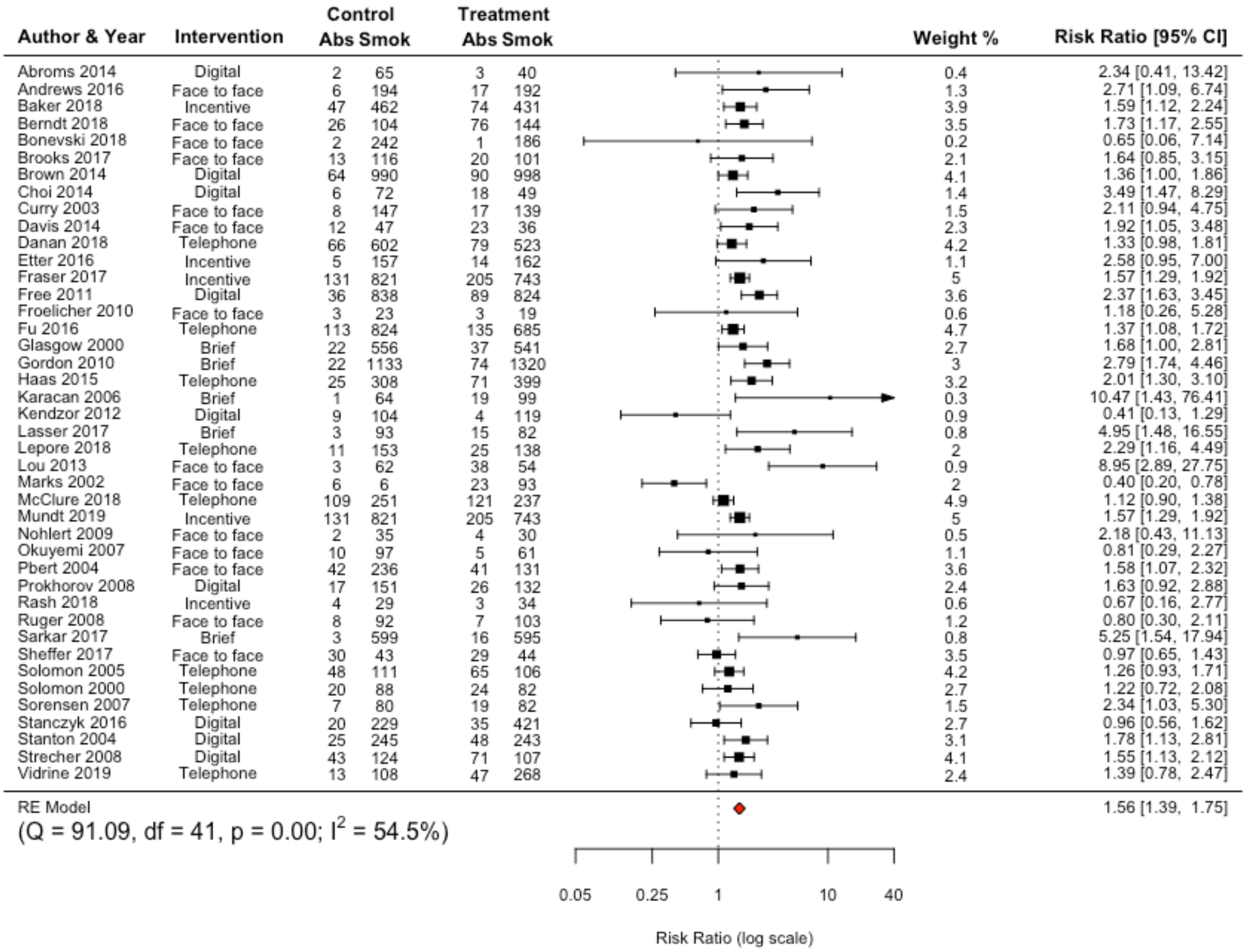
Figure 2.2: Methodological quality summary and risk of bias assessment *(continued)*

Study	The randomization process	Deviations from the intended interventions (effect of assignment to intervention)	Deviations from the intended interventions (effect of adhering to intervention)	Missing outcome data	Risk of bias in measurement of the outcome	Selection of the reported result	Overall judgement
Karacan 2006	?	?	+	+	-	+	-
Kendzor 2012	+	?	?	+	+	+	?
Lasser 2017	+	+	?	+	+	+	?
Lepore 2018	+	+	+	+	+	+	+
Lou 2013	+	?	?	?	+	+	?
Marks 2002	?	?	?	-	+	+	-
McClure 2018	+	+	+	+	?	+	?
Mundt 2019	+	?	+	?	+	?	?
Nohlert 2009	+	+	?	+	-	+	-
Okuyemi 2007	+	+	?	?	+	+	?
Pbert 2004	?	+	?	?	+	+	?
Prokhorov 2008	+	-	?	?	+	?	-
Rash 2018	+	+	?	+	?	+	?
Ruger 2008	+	?	+	+	+	+	?
Sarkar 2017	+	+	+	+	+	+	+
Sheffer 2017	+	?	+	+	+	+	?
Solomon 2005	?	+	+	+	?	?	?
Solomon 2000	?	+	+	?	?	?	?
Sorensen 2007	+	+	?	?	-	+	-
Stanczyk 2016	+	+	+	?	?	+	?
Stanton 2004	?	+	?	?	?	?	?
Strecher 2008	+	+	+	+	?	+	?
Vidrine 2019	+	+	+	+	?	?	?

Effects of interventions

A pooled effect size was estimated based on the 42 studies of SEP-tailored and non-SEP-tailored individual-level interventions in disadvantaged SEP groups (Figure 2.3). Disadvantaged individuals who participated in an intervention were significantly more likely to quit than disadvantaged individuals who acted as controls (RR=1.56, 95% CI 1.39 – 1.75, n = 26,168), resulting in an estimated increase in cessation by 39% to 75% after at least six months.

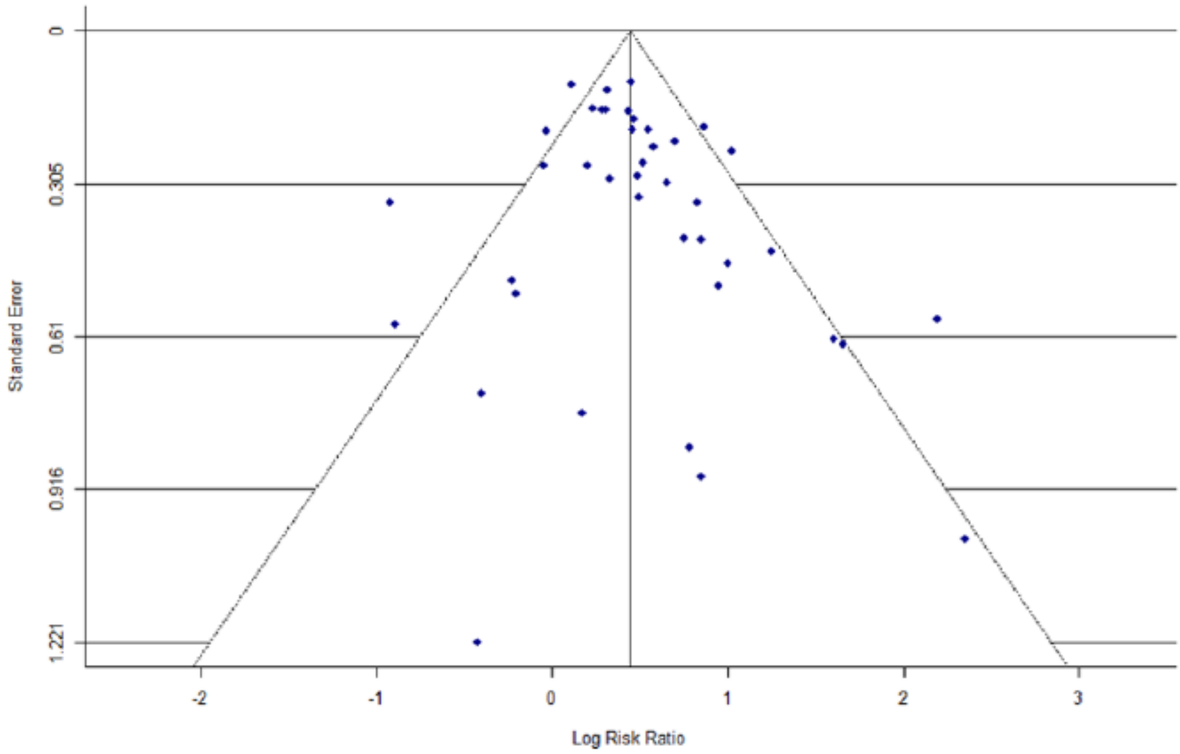
Figure 2.3: Forest plot of individual-level interventions compared with control/usual care in lower SEP groups. Outcome: Smoking cessation at ≥6 months follow-up.



*Abs = abstinent; Smok = smoking

There was some evidence of moderate heterogeneity in the effect size between trials ($I^2 = 54.5\%$). The certainty of evidence for this comparison was deemed to be moderate, and following Cochrane recommendations (where RCTs start with a baseline rating of 'High') downgraded from high due to plausible bias that was likely to seriously alter results. It was concluded that there were some concerns evident in all risk of bias assessment categories for the majority of studies. In these studies, it was not possible to blind those delivering interventions or participants given that they were receiving some form of behavioural intervention. Furthermore, where smoking cessation outcomes were self-reported and not biochemically validated, some risk of bias in outcome reporting was introduced as the participants were the outcome assessors rather than the research team.[192] A funnel plot suggested that there was no reporting bias for smoking cessation outcomes (Figure 2.4).

Figure 2.4: Funnel plot of studies included in primary meta-analysis using standard error of effect size and risk ratio of estimated outcome (smoking cessation)



*Standard error of effect size and risk ratio of estimated outcome (smoking cessation)

Association between tailoring and intervention effectiveness

In an unadjusted univariate model (Table 2.2), tailoring of interventions for disadvantaged groups was not associated with smoking cessation effect size. This absence of an association between tailoring of the intervention and intervention effect was also evident in the pre-planned model adjusted for the number of sessions delivered, whether interventions were delivered by a smoking cessation specialist, and whether the interventions involved the use of pharmacotherapy (Table 2.3, Model 1). However, there was evidence of some inter-correlation among study characteristics in model 1 whereby interventions that were delivered by a trained specialist generally involved a greater number of sessions (X-squared = 6.11, df = 1, p=0.029). Therefore, the number of sessions covariate was removed and the analyses re-run (Table 2.3, Model 2). Based on an expected effect size of RR 1.5 (see section 2.4), the calculated BF for model 2 (BF = 0.291) indicated weak evidence that there is no effect of tailoring on intervention effectiveness. Repeating the calculation based on an expected effect size of 1.1 indicated that the data were insensitive to detect small effects (BF = 0.81).

Table 2.2: Unadjusted univariate associations between intervention factors and effect size of intervention

Variable	Coefficient *B (SE)*	RR (95% CI)*	*p*	I^2	R^2adj
Tailored for low SEP[1]	-0.02 (0.13)	1.02 (0.79, 1.32)	.86	57.02%	0.00%
Trained specialist[2]	-0.23 (0.12)	0.79 (0.63, 0.99)	.05†	50.38%	13.65%
Pharmacotherapy[3]	0.27 (0.13)	1.31 (1.01, 1.68)	.05†	41.27%	41.20%
Number of sessions[4]	-0.01 (0.12)	1.00 (0.78, 1.27)	.99	56.55%	0.00%
Active Control[5]	-0.03 (0.13)	0.97 (0.75, 1.25)	.80	57.21%	0.00%
Type of support[6]	-0.26 (0.14)	0.77 (0.58, 1.02)	.06	52.21%	3.48%
Risk of bias[7]	-0.33 (0.18)	0.72 (0.51, 1.02)	.07	52.66%	5.81%
Biochemical verification[8]	-0.03 (0.13)	0.97 (0.74, 1.26)	.80	57.39%	0.00%
Intention to quit[9]	-0.06 (0.13)	0.94 (0.73, 1.20)	.60	56.28%	0.00%

*Risk Ratios (RR) calculated by exponentiating log-transformed estimates (B) of intervention effect.

Comparisons for binary variables: [1]SEP-tailored vs non SEP-tailored intervention; [2]Intervention involved provider trained in smoking cessation vs not; [3]Pharmacotherapy delivered vs not delivered. [4]Number of sessions delivered in intervention >4 vs ≤4; [5]Active control vs inactive control; [6]Digital or face to face/telephone intervention vs other intervention (financial incentives and brief interventions); [7]High/some concerns risk of bias vs low risk of bias; [8]Biochemically verified smoking cessation vs not.[9]Intention to quit vs no intention to quit. †p < .05

Table 2.3: Adjusted associations between tailoring and effect size of intervention

Model 1	Coefficient *B (SE)*	RR* (95% CI)	*p*
Variable			
Tailored for low-SEP[1]	-0.01 (0.12)	1.01 (0.80, 1.28)	.93
Trained specialist[2]	-0.28 (0.13)	0.76 (0.58, 0.98)	.04†
Pharmacotherapy[3]	0.24 (0.14)	1.27 (0.96, 1.67)	.09
Number of sessions[4]	0.11 (0.13)	1.12 (0.87, 1.45)	.38
Model 2			
Tailored for low-SEP[1]	0.01 (0.11)	1.01 (0.81, 1.27)	.93
Trained specialist[2]	-0.21 (0.11)	0.81 (0.65, 0.99)	.05†
Pharmacotherapy[3]	0.25 (0.13)	1.29 (0.99, 1.67)	.06

*Risk Ratios (RR) calculated by exponentiating log-transformed estimates (B) of intervention effect. Associations after mutual adjustment for all variables listed in Table 2.2.
Comparisons for binary variables: [1]SEP-tailored vs non-SEP-tailored intervention; [2]Intervention involved provider trained in smoking cessation vs not; [3]Pharmacotherapy delivered vs not delivered; [4]Number of sessions delivered in intervention >4 vs ≤4. †p < .05

Exploring heterogeneity

The exploratory unadjusted univariate models (Table 2.2) indicated that there was no evidence of an association between biochemical verification and smoking cessation effect size, but behavioural support (digital or in-person/telephone), studies with some concerns/high risk of bias and pharmacotherapy had meaningful associations (B > ±0.25) with effect size.

Compared with reference studies that involved financial incentives or brief interventions, digital or in-person/telephone behavioural support was negatively associated with intervention effectiveness for smoking cessation. Compared with studies that were deemed to have low risk of bias, some concerns/high risk of bias was negatively associated with intervention effectiveness. Provision of some of pharmacotherapy to participants was positively associated with intervention effectiveness, compared with the reference interventions that did not provide pharmacotherapy.

The adjusted model that included these three variables deemed to be meaningful reduced the heterogeneity in the effect size between trials (I^2 = 16.55%, R^2adj = 82.09%, p =

0.0027) compared with the result from the primary meta-analysis (I^2 = 54.50%) (Table 2.4).

Table 2.4: Adjusted associations between intervention factors deemed meaningful and effect size of intervention

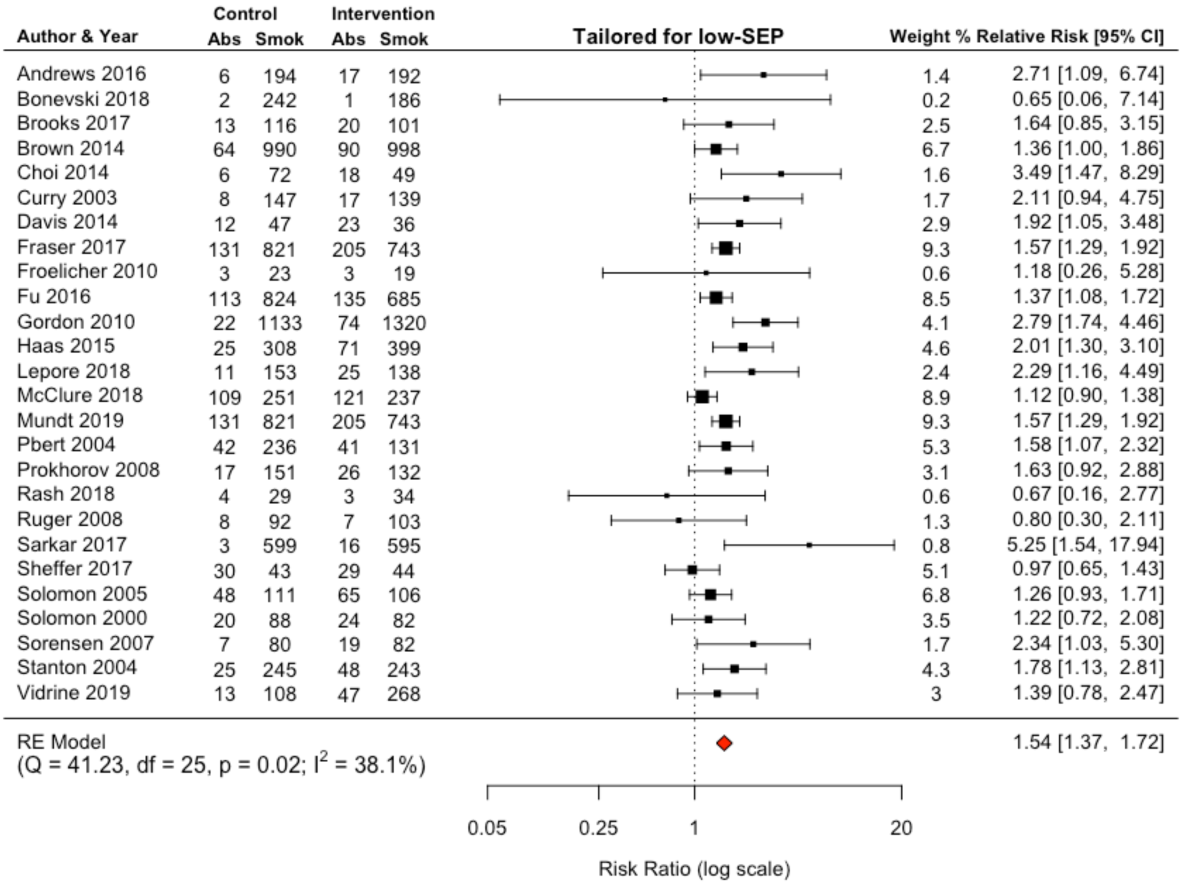
Variable	Coefficient *B (SE)*	RR* (95% CI)	*p*
Pharmacotherapy[1]	0.31 (0.11)	1.37 (1.10, 1.71)	.004*
Type of support[2]	-0.37 (0.10)	0.76 (0.62, 0.91)	.004*
Risk of bias[3]	-0.34 (0.13)	0.71 (0.55, 0.93)	.01†

*Risk Ratios (RR) calculated by exponentiating log-transformed estimates (B) of intervention effect. Associations after mutual adjustment for all variables listed in Table 2.2.
Comparisons for binary variables: [1]Pharmacotherapy delivered vs not delivered. [2]Digital or behavioural intervention vs other intervention (financial incentives and brief interventions); [3]High/some concerns risk of bias vs low risk of bias.
†p < .05.*p<.01

Tailored interventions for smoking cessation versus control/usual care

A pooled effect size was estimated based on the 24 studies of SEP-tailored interventions (Figure 2.5). Disadvantaged individuals who participated in an SEP-tailored intervention were significantly more likely to quit than disadvantaged controls (RR=1.54 (95% Confidence Interval (CI) 1.37 – 1.72, n = 17,952) with some evidence of heterogeneity in the effect size between trials (I2 = 38.10%). The certainty of evidence for this comparison was deemed moderate for the same reasons as those outlined above for the primary analysis involving all studies.

Figure 2.5: Forest plot of SEP-tailored individual-level interventions compared with control/usual care in socio-economically disadvantaged groups. Outcome: Smoking cessation at ≥6 months follow-up.



*Abs = abstinent; Smok = smoking

Non-SEP-tailored interventions for smoking cessation versus control/usual care – low- and high-SEP participants

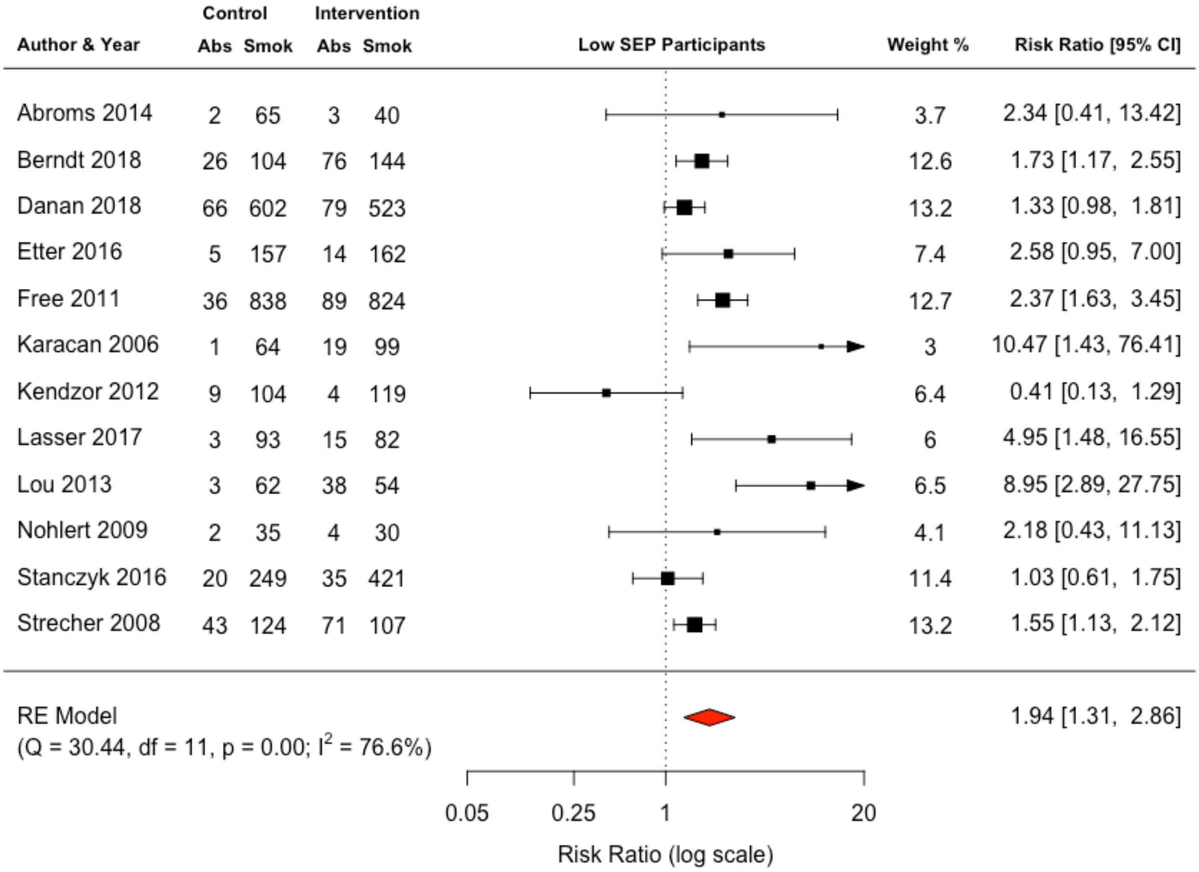
Pooled effect sizes were estimated separately for disadvantaged participants (Figure 2.6) and advantaged participants (Figure 2.7) based on the 12 studies of non-SEP-tailored interventions that reported outcomes. Four non-SEP-tailored interventions were excluded from this comparison as they were delivered in a disadvantaged context and did not provide outcome data for more participants of more advantaged SEP. Disadvantaged SEP and advantaged SEP individuals who participated in a non-SEP-tailored intervention were significantly more likely to quit than controls. However, there was evidence of high heterogeneity in the effect size between trials ($I^2 = 76.6\%$ and $I^2 = 82.7\%$ respectively). This heterogeneity was partially reduced in univariate meta-regression models including the number of sessions included as the study-level variable (reduced $I^2 = 64.63\%$ in the analysis including only low-SEP participants, and $I^2 = 75.29\%$ in the analysis including only high-SEP participants). No other study-level covariates were able to reduce heterogeneity. The results of the sub-group analysis (Appendix 4) are presented in Table 2.5 below and suggest that there were no apparent differences between the estimates of smoking cessation according to whether the participants in non-SEP-tailored interventions were lower or higher SEP.

Table 2.5: Subgroup analysis of smoking cessation among low vs high-SEP participants in non-SEP-tailored interventions

	Coefficient *B (SE)*	**Z value**	***p***	95% CIs
Intercept	0.69 (0.20)	3.54	.001	0.309 - 1.08
LowSEP	-0.03 (0.28)	-0.12	.90	-0.59 - 0.52

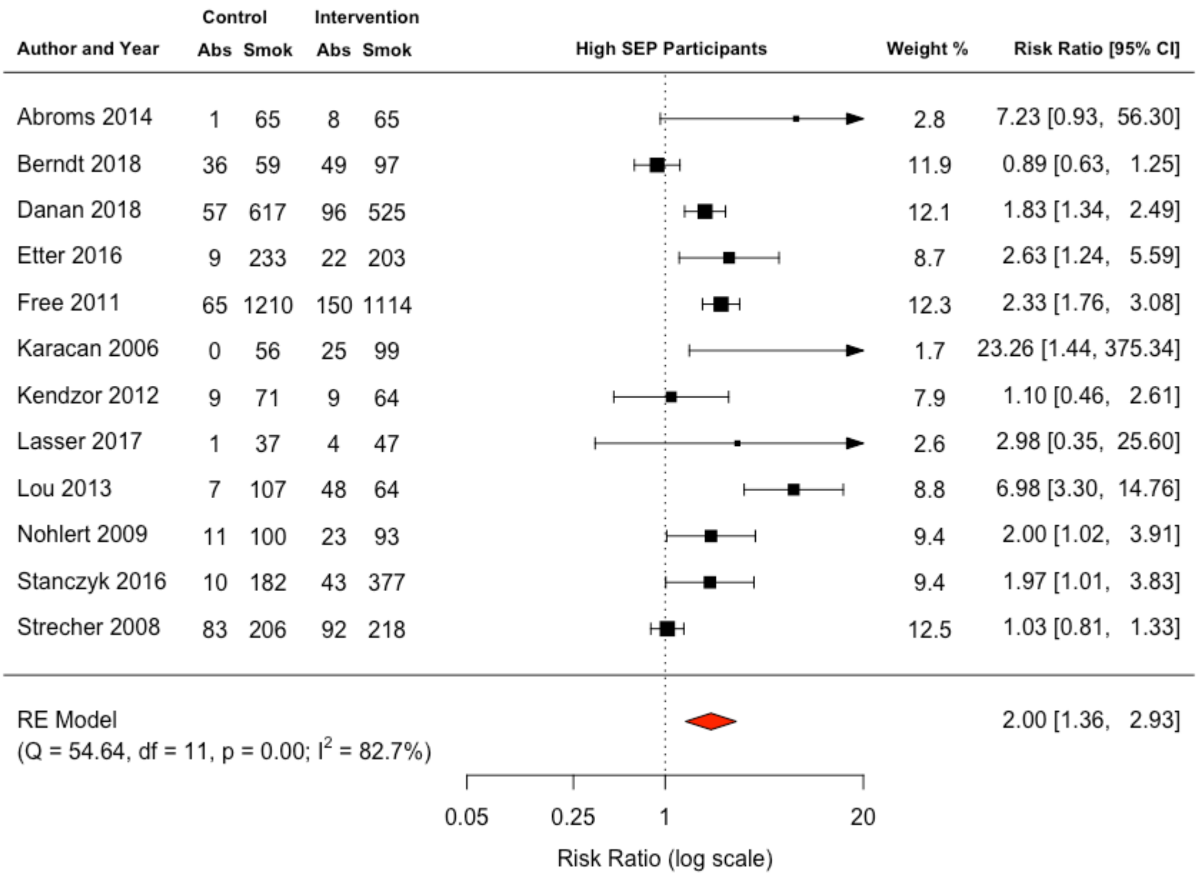
Fixed-effects with moderators model
Test for Residual Heterogeneity: QE(df = 0) = 0.000, p-val = 1.000
Test of Moderators (coefficient 2): QM(df = 1) = 0.000, p-val = 0.904

Figure 2.6: Forest plot of non-SEP-tailored individual-level interventions compared with control/usual care in low-SEP participants.



*Abs = abstinent; Smok = smoking

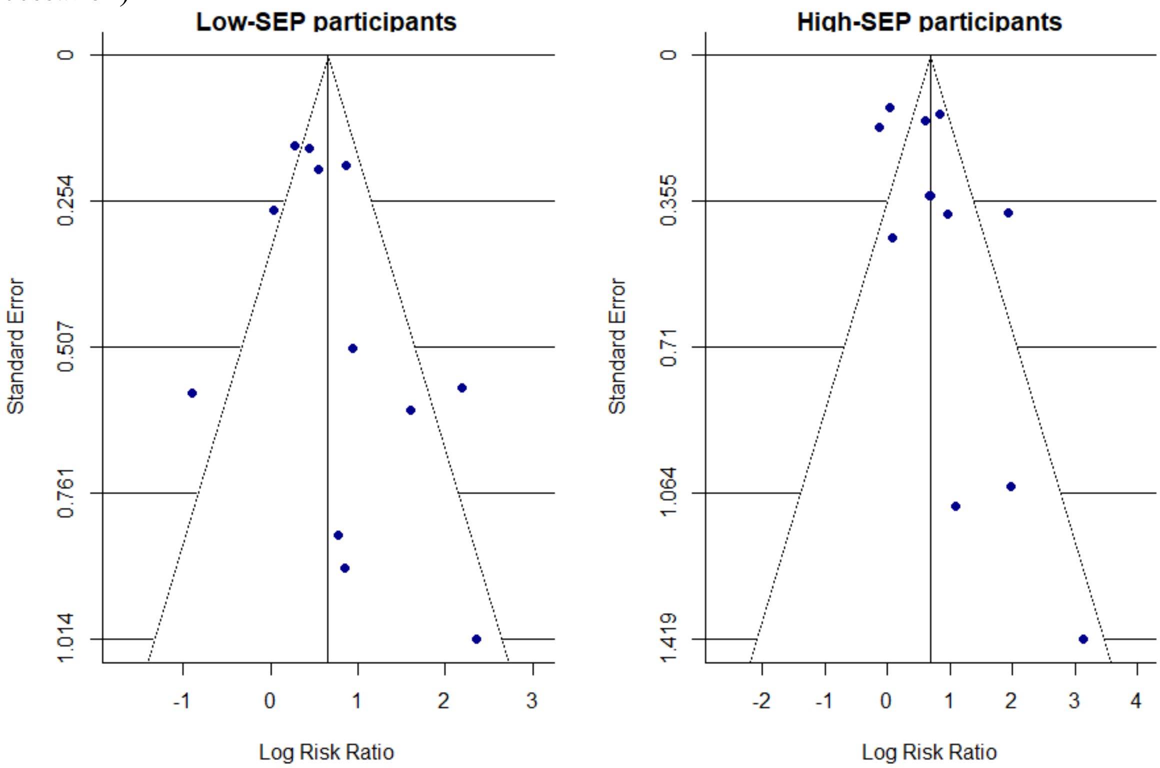
Figure 2.7: Forest plot of non-SEP-tailored individual-level interventions compared with control/usual care in high-SEP participants.



*Abs = abstinent; Smok = smoking

Plausible bias was possible in the six studies where smoking cessation outcomes were self-reported and not biochemically validated. In these cases, the outcome assessor was the study participant rather than the research teams conducting the studies. Finally, funnel plots (Figure 2.8) indicated potential reporting bias due to studies suggesting a beneficial effect being more likely to be published than non-significant results. Egger's test for funnel plot asymmetry was non-significant with respect to the low-SEP participant analysis, but significant for the high-SEP analysis (see Appendix 4). However, given the high levels of heterogeneity and relatively small number of studies included in the test for asymmetry, the analysis may not be sufficiently powered to distinguish between real asymmetry and chance.[239]

Figure 2.8: Funnel plot of non-SEP-tailored interventions (low- and high-SEP participants) standard error of effect size and risk ratio of estimated outcome (smoking cessation)



*Standard error of effect size and risk ratio of estimated outcome (smoking cessation)

2.6 Discussion

There is consistent evidence that individual-level interventions for smoking cessation in socio-economically disadvantaged groups are effective for smoking cessation, with an estimated increase in cessation by 39% to 75% after at least six months (based on 42 studies with over 26,000 participants). However, there was no evidence that tailoring interventions for low-SEP smokers significantly moderated effectiveness compared with non-SEP-tailored interventions. The sensitivity analyses using Bayes factors indicated that there were no large (RR=1.5) moderating effects. However, further analysis suggested that the data were insensitive to detect smaller moderating effects (RR = 1.1). The certainty of evidence for individual-level interventions overall was moderate but the estimates for subgroups should be interpreted with caution given that overall the evidence from these studies was deemed to be of low certainty.

Tailored individual-level approaches have been expected to play an important role in reducing health inequalities by addressing some of the needs specific to disadvantaged smokers such as access to support, improving self-efficacy and understanding the harms and mechanisms of smoking. However, results from this study imply that such tailoring has not yet improved effectiveness compared with non-SEP-tailored approaches. Nevertheless, they appear equally effective so existing programmes – which are not substantially more expensive - should not be abandoned without replacement.[115, 180] Rather, to improve rates of smoking cessation among disadvantaged smokers a new, multi-faceted approach is required at the individual, community and population level. Compared with those of more advantaged SEP, low-SEP individuals face more facilitators to smoking uptake (particularly relevant for youth uptake as tobacco use typically begins in childhood or adolescence), and more barriers to quitting (Table 1.2)[46], which may outweigh the benefits of tailoring of the interventions at the individual level. Further research is necessary to assess whether interventions could be further adapted and improved in order to extend the benefits into longer-term success.

In this current review, comparing the results from separate meta-analyses conducted using data from low-SEP and high-SEP participants from the same trial estimated that the effects of non-SEP-tailored interventions on smoking cessation were similar. This contrasts with a previous review[114] which suggested that non-SEP-tailored smoking cessation support interventions were likely to be equity negative (the interventions helped participants with high-SEP to quit more than disadvantaged low-SEP participants). This divergence should, however, be interpreted with caution as the inclusion criteria between the studies differed. This current review only included RCTs of individual-level interventions (including face to face and digital behavioural support interventions and financial incentives) measuring smoking cessation at least six months after baseline. The previous review largely focussed on face-to-face behavioural support and included observational and correlational designs, and RCTs that involved the use of pharmacotherapy alone. Furthermore, in response to inequalities in access, provision of smoking cessation services in some low-SEP areas of the UK has been improved, with results from programmes in Scotland indicating improvements in quit success among disadvantaged smokers.[115] These data support the finding from this current review, where non-SEP-tailored interventions appear to have similar effectiveness for quit success across the social gradient, if access to such services are provided.

Nine studies included in this review recruited women only whereas one study recruited men only. This focus may reflect the phenomenon of higher smoking rates and health inequalities among disadvantaged ethnic minority women in the USA[240], along with the potential opportunity for a smoking cessation intervention when women are in clinic either during or following pregnancy. In many contexts ethnicity is intersected with disadvantage and there is often overlap in the use of SEP-tailored interventions that account for this, for example, the African American community in the USA.[199] This was judged beyond the scope of my review because tailoring on this dimension is especially complex due to the need to involve cultural adaptation and the variety of ethnic distributions.

Thirty of the included studies used point prevalence (7-day or 30 day) rather than sustained (continuous abstinence from smoking for a specified period of time such as 30 days) abstinence outcomes. While there is some debate as to which measure is more robust, a comparative systematic review concluded that they are highly correlated and produce similar effect sizes for smoking cessation.[241]

Strengths and limitations

The results from this review should be interpreted with some caution given limitations and challenges inherent in conducting a meta-regression. First, exploring sources of heterogeneity as was done for a range of covariates in this review may result in false-positive conclusions. Although several covariates were pre-specified in the review protocol (use of pharmacotherapy, intervention delivered by a smoking cessation specialist and the number of intervention sessions), it was not possible to do the same for all other potentially important covariates in an appropriate manner. In this regard, the finding that pharmacotherapy, risk of bias and digital/behavioural interventions reduced heterogeneity compared with the primary meta-analysis should be viewed as exploratory and hypothesis-generating rather than hypothesis testing.

Second, it is possible that study characteristics included in the meta-regression were highly correlated, such that an observed association with one study characteristic is in fact reflective of a true association with another correlated characteristic that has not been measured. For instance, there was some evidence of clustering of study characteristics in this review whereby more sessions appeared to take place if a trained specialist was delivering the intervention. The coefficient for the number of sessions variable was inflated when these two variables were included in the adjusted a model. It also remains possible that the effectiveness of behavioural support depended on the skill of the practitioner delivering it.[242] Unfortunately, a variable to assess practitioner skill was not available for most studies analysed, so meaningful adjustment for this was not possible. However, such effects are generally relatively small[240] and so unlikely to have overly biased results. Further, since study quality (which measures bias in trials) was included in the meta-regression, an attempt was made to account for therapist effects as far as possible given the available information. The risk of bias assessment included deviations from the intended interventions. In cases where original study provided no information on this point, the potential bias was noted and included in the final assessment for overall risk of bias. Other measures of effectiveness for smoking cessation in interventions tailored for disadvantaged groups, such as time to relapse and abstinence at earlier follow-up time-points may provide a more nuanced picture of study results. However, improving smoking cessation in the long-term must remain an important goal in intervention design and measurement of abstinence at six months is a more robust measure of this.

There are potential limitations related to the operationalisation of SEP in this review. Despite 39 out of 42 studies being conducted in a high-income country, there are often between country differences in terms of how SEP is experienced and how it influences health behaviour.[25] Furthermore, it is possible that the SEP of the underlying sample populations in each study differed between SEP-tailored and non-SEP-tailored interventions. If this were to be true, then any apparent effectiveness of non-SEP-tailored interventions for low-SEP smokers discussed in this review may reflect the recruitment of comparatively more socio-economically advantaged participants than in the trials of the SEP-tailored interventions. It would therefore be possible that had the disadvantaged participants in the studies of SEP-tailored interventions received a non-SEP-tailored intervention, their abstinence rates would have been lower. Furthermore, trials of non-SEP-tailored interventions that report outcomes by SEP may differ from non-SEP-tailored interventions that do not report this. Such studies may pay more attention to SEP issues despite not explicitly reporting on tailoring of the intervention to SEP populations. This may underestimate the moderating effect of SEP tailoring. Future research in this field may consider using a standardised index of SEP to allow valid comparison between levels of disadvantage and deprivation across populations. However, these considerations were outside the scope of this current review and would likely involve the creation of some form of standardised index of SEP to allow valid comparison between levels of deprivation across populations that are measured using differing indicators of SEP. Indeed, certain indicators of SEP such as housing tenure have recently been shown to be strongly associated with the social gradient in smoking[243] and as such will be a useful proxy in future studies.

During the study screening process, it became evident that relevant studies (n = 169) might have been excluded because they did not report their outcomes by SEP, despite potentially recruiting a socio-economically diverse sample of participants. Given the evidence of persistent inequalities in smoking rates worldwide, it essential that smoking cessation trials endeavour to collect and report outcomes by SEP. One important reason that this should be a specific requirement of trials is to ensure that positive findings of treatment effect in high-SEP smokers are not falsely generalised to other populations such as disadvantaged smokers who may not respond to the intervention in a favourable way. Studies are typically not powered to conduct robust sub-group analyses by SEP, but if outcomes are reported in this way then they can be cumulatively included in pooled effect-size estimates in future reviews in a similar way to that which was attempted in this current review.

Finally, the certainty of evidence of studies included in this review was rated as moderate for the primary analysis and low for the secondary analyses. It therefore remains possible that the true effects are substantially different than what was estimated.

Despite these challenges and limitations, this study has several strengths. To my knowledge, no previous reviews have examined the overall effect of all types of individual-level behavioural support interventions for smoking cessation in socio-economically disadvantaged groups and extended the analysis to examine whether SEP-tailoring moderates the effectiveness of individual-level behavioural smoking cessation interventions at ≥6- months in socio-economically disadvantaged groups. The inclusion of 42 studies made it possible to conduct a meta-regression analysis, which is a useful tool to extend the analysis and relate the size of treatment effect in clinically and methodologically diverse studies to relevant study characteristics. Considering the growing number of interventions that involve some form of tailoring for disadvantaged groups, this analysis is an important step towards gathering evidence about their effectiveness. It may also encourage further equity-focussed research that will improve the effectiveness of smoking cessation programmes.

2.7 Conclusion

This systematic review and meta-regression highlighted that both SEP-tailored and non-SEP-tailored individual-level interventions for smoking cessation in socio-economically disadvantaged groups are effective for smoking cessation. However, there are currently no large moderating effects of tailoring interventions for disadvantaged smokers. Future research in this area should consider assessing what the most effective components of SEP-tailored interventions are by using an appropriate theory-informed taxonomy such as the behaviour change technique taxonomy[70], extending work that is currently being conducted as part of the IC-SMOKE project.[73]

Given the challenges in designing effective and equity-positive SEP-tailored interventions, and that, at least in the UK, resources for smoking cessation services have seen consistent cuts in recent years, other innovative smoking cessation products should also be considered. Due to their popularity (see section 1.6.2), e-cigarettes have disrupted the smoking cessation market and current evidence suggests that they are more effective than conventional nicotine replacement therapies, conferring much less harm to the user compared with tobacco cigarettes. In the context of consistent declines in smoking in England over the past decade, the rapid rise in the use of e-cigarettes poses questions about their relationship with socio-economic inequalities in smoking cessation. The devices have been available for over a decade in the UK, and survey data from the STS allows emerging trends in use to be examined according to SEP. Using STS data, Chapters 3 and 4 analyse these population-level trends in detail, providing an up-to-date examination of the associations between SEP and current e-cigarette use in important subgroups of smokers and ex-smokers. At this stage differential usage and effectiveness for smoking cessation in different groups has the potential to either widen or reduce the existing smoking related inequalities outlined in section 1.3.

Chapter 3

The socio-economic gradient in e-cigarette use in England 2014-2017 (Study 2)

Reference for publication (full paper in Appendix 2): Kock, L., Shahab, L., West, R. and Brown, J., 2019. E-cigarette use in England 2014–17 as a function of socio-economic profile. *Addiction*, *114*(2), pp.294-303.

Abstract

E-cigarettes are the most popular support used in quit attempts in England and could either decrease or increase health inequalities depending on socio-economic differences in their use. This study assessed the associations between socio-economic position (SEP) and e-cigarette use and whether these associations changed between 2014 and 2017. Data on e-cigarette use were collected from representative samples totalling 81,063 adults in England who took part in cross-sectional surveys between January 2014 and December 2017. Logistic regression models (adjusting for age, region and sex) were constructed to assess associations between SEP and e-cigarette use among all adults, past-year smokers, smokers during a quit attempt and long-term (>1-year) ex-smokers. The models were stratified by year to assess the changes in these associations over time.

Among all adults there was a socio-economic gradient in the prevalence of e-cigarette use, with adults from SEP group E having twice the odds of using an e-cigarette compared with the most advantaged SEP group AB (E: odds ratio (OR)=2.23, 95% CI 1.75-2.84). Among past-year smokers, lower SEP groups had lower overall odds of e-cigarette use

compared with AB (D: OR=0.53, 95% CI 0.40-0.71; E: 0.67, 0.50-0.89). However, these differences in e-cigarette use depending on SEP group reduced over time and were largely absent by 2017. The use of e-cigarettes during a quit attempt showed no clear temporal or socio-economic patterns. Among long-term ex-smokers, use of e-cigarettes increased from 2014 to 2017 among all groups and use was more likely in SEP groups C2 (OR=2.03, 95% CI 1.08-3.96) and D (OR=2.29, 1.13-4.70) compared with AB.

From 2014 to 2017 in England, e-cigarette use was more prevalent among advantaged smokers compared with lower SEP smokers, but this difference lessened over time and was no longer present by the end of the time period. E-cigarette use specifically during a quit attempt was similar across SEP groups throughout the period. The use of e-cigarettes by long-term ex-smokers increased over time among all groups and was consistently more common in more socio-economically disadvantaged groups.

3.1 Background

As outlined in section 1.6.2, e-cigarettes have rapidly become the most popular cessation devices in several high-income countries including the USA[244] and UK[131], and are associated temporally with population-level improvements in success rates of cessation attempts.[140,244] Modelling e-cigarettes substituting cigarettes over a 10-year period indicates that 1.6 million premature deaths would be averted in the USA even under a pessimistic scenario. This scenario assumes the harm reduction to be 60% compared with cigarettes and 150% more e-cigarette initiation beyond simply replacing those who would have smoked in their absence.[153]

In England e-cigarettes can be bought from vaping shops, pharmacies and other retail outlets, with advertising restrictions in place under the European Union TPD (section 1.6.3). Recent estimates from the STS indicate that current smokers spend on average £23.09 on smoking each week, compared with ex-smoking e-cigarette users who spend on average £8.03 on e-cigarettes each week.[245]

Consistent with the theory of diffusion of innovations (section 1.6.6.1), some data has suggested that use and awareness of e-cigarettes was greater among more advantaged 'early adopters' during the years in which the devices first became popular.[164,165] E-cigarette use by adults in England appears to have stabilised since late 2013[131], which provides an opportunity to assess the extent to which the socio-economic profile of e-cigarette users in England has changed.

Health inequalities (section 1.4) are present in all countries worldwide irrespective of economic status and human development index. Life expectancy and the possibility of living a healthy life are strongly related to the material, social, political and cultural conditions in which individuals and families live.[110] It is widely observed that those of more advantaged SEP have better health.[29] Smoking prevalence and its associated morbidity and mortality are also socio-economically patterned, and although overall smoking prevalence in England is declining (estimated to be 14.4% in 2018[26], smoking prevalence is at least twice as high among lower socio-economic groups compared with more affluent groups (section 1.3).

As an effective and popular smoking cessation aid in England, e-cigarettes present a potentially useful tool to reduce smoking prevalence across the socio-economic spectrum.[121] However, it is possible that e-cigarettes could widen inequalities in smoking[114] if 'early adopters' disproportionately come from more advantaged socio-economic groups. Previous studies on e-cigarette use have often measured 'ever use' or 'past 30-day use' and operationalised these as proxies of current use.[163] These categorisations likely reflect infrequent usage, and more robust measures of current use, such as daily use, should be employed instead. Furthermore, rather than focussing on overall e-cigarette use among all adults, a more nuanced understanding of use in the population is granted by examining patterns of use among sub-groups of smokers and ex-smokers who are at different stages of transition from smoking to ex-smoking. This is also important considering that sub-groups may display varying socio-economic characteristics. There is limited data on the use of e-cigarettes stratified by SEP at the population level and innovation in the technologies of nicotine delivery is fast evolving.[246] It is therefore important to examine their use and any associated trends associated with SEP.

Using data from the smoking toolkit study (STS) collected between 2014 and 2017, the aims of this study were to i) examine whether there are associations between SEP and current e-cigarette use, ii) examine whether associations between SEP and current e-cigarette use vary annually from 2014 to 2017, iii) conduct sensitivity analyses redefining current e-cigarette use for those reporting daily and weekly e-cigarette use and, given that SEP is a broad construct that can be measured using multiple proxies (section 1.3), iv) conduct sensitivity analyses using housing tenure as an alternative measure of SEP.

3.2 Methods

3.2.1 Design

This repeated cross-sectional survey study used annual data collected between January 2014 and December 2017 from the STS[27], a large nationally representative survey of smoking and smoking cessation in England. The years 2014 to 2017 were chosen because they cover four full years since e-cigarette use by adults stabilised in England in late 2013. The STS involves monthly cross-sectional household computer-assisted interviews of 1700-1800 adults aged 16+ in England, conducted by the market research company Ipsos MORI. Sampling of participants for the baseline survey uses a hybrid of random probability and simple quota sampling. This involves assorting England into over 170,000 initial output areas made up of approximately 300 households, stratified by the nine regions of England and the geodemographic profiling tool ACORN (see http://www.caci.co.uk/acorn/). Interviews are then conducted with a single member of households within randomly assigned stratified output areas. This continues in each area until quotas based on area demographics are fulfilled. A response rate cannot be calculated because there is no predefined gross sample in the sample framework. Given the high number of output areas included in each wave, which are themselves randomly sampled from over 170,000 initial output areas, it is unlikely that there are substantial clusters resulting in bias.

All cases were weighted using the rim (marginal) weighting technique to match the English population profile relevant to the time each monthly survey was collected on the following variables: age, social grade, region of England, housing tenure, ethnicity and working status within sex derived from English census data, Office for National Statistics mid-year estimates and other random probability surveys. The weighting involved an iterative sequence of adjustments whereby a weight was applied to each respondent such that the monthly sample matched specified targets on a first dimension, before being adjusted iteratively to match on a second dimension. This was continued until the final dimension had been matched and a good match across dimensions had been achieved. The STROBE guidelines were used in the design and reporting of this study.[247]

3.2.2 Measures

Along with all adults, three sub-groups were chosen for the analysis because of their relevance to patterns of e-cigarette and combustible cigarette use among current and former smokers in the population[163] (see section 3.1):

i) Past-year smokers;

ii) Quit attempters;

iii) Long-term ex-smokers

Responders who answered ‘Yes’ to the question “Smoked in past-year” were identified as past-year smokers.

Responders who answered ‘Yes’ to the question “Whether tried to quit in past-year” were identified as past-year quit attempters.

Responses to the question “Smoking status” were used to identify respondents who were long-term ex-smokers. Responders who selected the answer option “Stopped >1y ago” were classified as long-term ex-smokers.

The outcome variable of current e-cigarette use among adults, past-year smokers and long-term ex-smokers was derived from responses of ‘Electronic cigarette’ to the following questions:

1. “Can I check, are you using any of the following?”;
2. “Whether using products to help cut down the amount smoked”;
3. “Whether use products to cut-down, stop smoking or for any other”;
4. “Whether regularly use e-cigarettes in situations where NOT allowed to”.

E-cigarette use during a quit attempt was derived from a response of ‘Electronic cigarette’ to the following question: “What used to try to help stop smoking during the most recent serious quit attempt”.

In the main analyses respondents were stratified by SEP using the National Readership Survey (NRS) classification system for social grade based on occupation of the chief income earner. Social grade has useful discriminatory power as a target group indicator.[248] The NRS classification system consists of five levels: AB (Higher and intermediate managerial, administrative and professional); C1 (Supervisory, clerical and junior managerial, administrative and professional); C2 (Skilled manual workers); D (Semi-skilled and unskilled manual workers); E (State pensioners, casual and lowest grade workers, unemployed with state benefits only). The social grade proxy for SEP is therefore operationalised along a socio-economic gradient starting at AB which refers to those who are most advantaged, compared with D and E which represent those who are more disadvantaged.

In the sensitivity analysis, housing tenure classification was used as an alternative measure of SEP[249] and was collapsed to include two groups 'Social housing' (local authority or housing association) and 'Other' (mortgage bought, owned outright, private renting and other).

Sociodemographic characteristics

Sex (categorised as women or other), age (categories 16-24, 25-34, 35-44, 45-54, 55-64, 65+) and region in England (London, North East, North West, Yorkshire and Humber, East Midlands, West Midlands, East of England, South East, South West) were also measured. I included these variables a priori because e-cigarette use differs according to age, sex and region in England.

3.2.3 Analysis

The analysis plan was pre-registered on the Open Science Framework (OSF) https://osf.io/8zdgy/. Analyses were conducted using R version 3.4.1. All scripts and relevant STS variables were saved for replication and are available on OSF.

To assess the trends in the associations between SEP and current e-cigarette use (a binary outcome), logistic regression models were constructed with social grade operationalised as the socio-economic explanatory variable (five categories with AB as the referent) and year (four categories with 2014 as the referent year), and their interaction term. Social grade was treated as a discrete unordered predictor variable rather than an ordinal predictor variable because despite it being a useful proxy for SEP, differences between categories of social grade based on occupation are inconsistent; a unit change from social grade AB (Higher and intermediate managerial, administrative and professional) to C1

(Supervisory, clerical and junior managerial, administrative and professional) is not equivalent to a unit change from C1 to C2 (Skilled manual workers).

Odds ratios with 95% confidence intervals (adjusted for sex, region, and age) were reported. To examine the interaction between social grade and year, the associations between social grade and e-cigarette outcomes were reported stratified by year.

My analyses are reported in four tables:

i. Current e-cigarette use among all adults by social grade
ii. Current e-cigarette use among past-year smokers by social grade
iii. E-cigarette use during a quit attempt among smokers by social grade
iv. Current e-cigarette use among long-term ex-smokers by social grade

In sensitivity analyses, the analyses were repeated with current use redefined to i) those reporting daily e-cigarette use and ii) those reporting at least weekly e-cigarette use. For the past-year quit attempter subgroup, daily and at least weekly use of e-cigarettes reflected respondents who were still currently using the devices following their quit attempt, rather than daily or weekly usage during the quit attempt itself. Further sensitivity analyses were conducted using housing tenure as an alternative measure of SEP (Social housing and ‘Other’ (referent)).

3.3 Results

A weighted total of 81,063 individuals completed the baseline survey between January 2014 and December 2017. Table 2.1 contains an overview of the sample characteristics.

The long-term ex-smokers (quit >1-year ago) had stopped smoking for a mean of 20.5 and median 25 years.

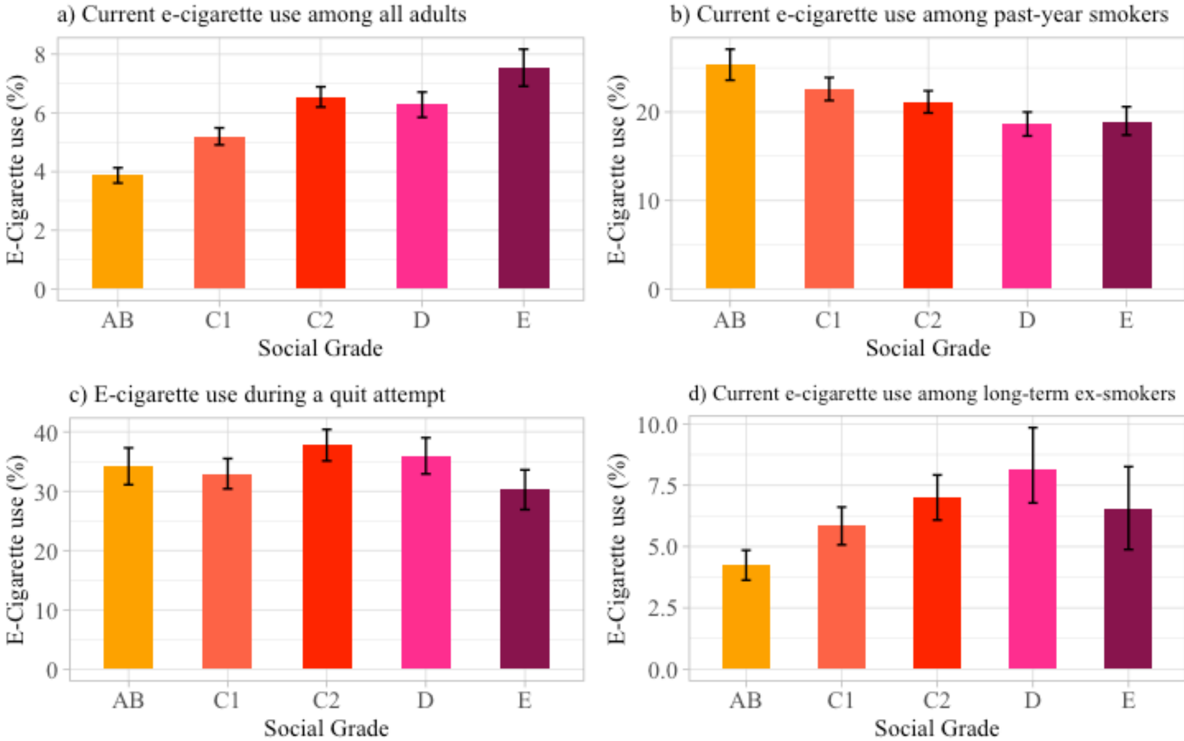
Table 3.1: Characteristics of sample (weighted data)

Variables	**All adults** n (%)	**Past-year smokers** n (%)	**Quit attempt** n (%)	**Long term ex-smokers** n (%)
Overall sample	81063 (100)	16232 (100)	5305 (%)	13562 (100)
E-cigarette use*				
Yes	4450 (5.5)	3460 (21.3)	1833 (34.6)	801 (5.9)
No	76613 (94.5)	12772 (78.7)	3472 (65.4)	12761 (94.1)
Sex				
Men	40986 (49.0)	8615 (53.1)	2707 (51.0)	7204 (53.1)
Women	40054 (51.0)	7615 (46.9)	2598 (49.0)	6355 (46.9)
Age				
16-24	11612 (14.3)	2931 (18.1)	978 (18.4)	357 (2.6)
25-34	13571 (16.7)	3617 (22.2)	1350 (25.4)	1271 (9.4)
35-44	13430 (16.6)	2990 (18.4)	1067 (20.1)	1929 (14.2)
45-54	14073 (17.4)	2968 (18.3)	932 (17.6)	2411 (17.8)
55-64	11370 (14.0)	2028 (12.5)	580 (10.9)	2522 (18.6)
65+	17006 (21.0)	1698 (10.5)	398 (7.5)	5070 (37.4)
SEP				
AB	21938 (27.1)	2445 (15.1)	920 (17.3)	4358 (32.1)
C1	22300 (27.5)	3932 (24.2)	1352 (25.5)	3711 (27.4)
C2	17675 (21.8)	4182 (25.8)	1327 (25.0)	3066 (22.6)
D	12189 (15.0)	3309 (20.4)	970 (18.3)	1543 (11.4)
E	6960 (8.6)	2364 (14.6)	736 (13.9)	885 (6.5)

*E-cigarette use is defined as current use for all adults, past-year smokers and long-term ex-smokers. For the quit attempt subset, e-cigarette use was defined as using an electronic cigarette during the most recent quit attempt.

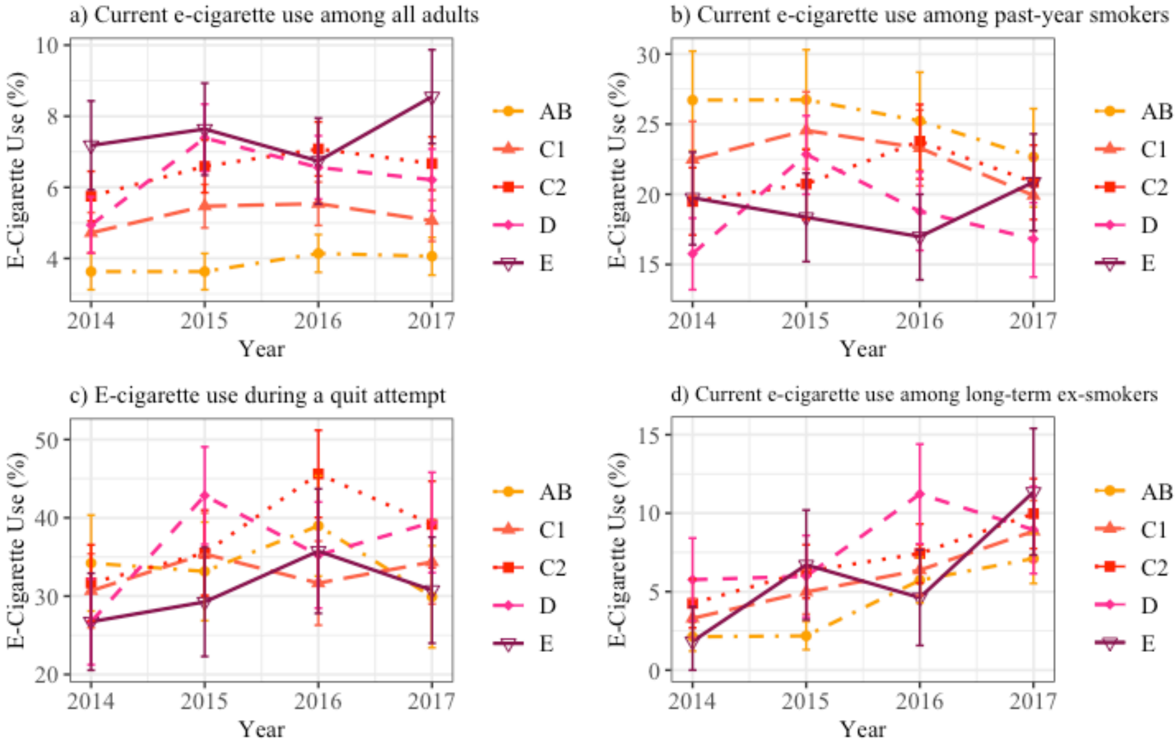
Between 2014-2017, 5.49% (95% CI 5.33-5.65; N=4,450) of all adults, 21.32% (95% CI 20.69-21.96; N=3,460) of past-year smokers, 34.55% (95% CI 33.26-35.84; N=1,833) of smokers attempting to quit, and 5.91% (95% CI 5.51-6.31; N=801) of long-term ex-smokers indicated that they currently used an e-cigarette. Weighted prevalence statistics for e-cigarette use in the four groups of interest are shown for the overall time period in Figure 3.1 (a-d), and for each year (From 2014 to 2017 in Figure 3.2 (a-d).

Figure 3.1 a-d: Overall prevalence of e-cigarette use in England by social grade (all years 2014-2017, weighted data)



Long term ex-smokers refer to individuals who stopped smoking >1 year ago. Social grades: AB=Higher and intermediate managerial, administrative and professional, C1=Supervisory, clerical and junior managerial, administrative and professional, C2=Skilled manual workers, D=Semi-skilled and unskilled manual workers, E=State pensioners, casual and lowest grade workers, unemployed with state benefits only.

Figure 3.2 a-d: Prevalence of e-cigarette use in England 2014 to 2017 by social grade (weighted data)



Long term ex-smokers refer to individuals who stopped smoking >1 year ago. Social grades: AB=Higher and intermediate managerial, administrative and professional, C1=Supervisory, clerical and junior managerial, administrative and professional, C2=Skilled manual workers, D=Semi-skilled and unskilled manual workers, E=State pensioners, casual and lowest grade workers, unemployed with state benefits only.

All adults

From 2014-2017, there was a socio-economic gradient in the prevalence of e-cigarette use with adults from social grade E having twice the odds of using an e-cigarette compared with those from AB (Table 3.2). There was no time trend across all social grades and little interaction between social grade and time. The exception was that prevalence in D compared with AB depended on year, with higher comparative prevalence in 2015 compared with 2014 (Table 3.2 and Figure 3.2a). When the associations were stratified by year, the odds of e-cigarette use were greater among more disadvantaged social grades compared with AB in each year (Table 3.2).

Table 3.2: Associations between e-cigarette use and SEP among all adults in England 2014-2017

	Overall (N=81057)	2014 (N=20192)	2015 (N=20034)	2016 (N=20436)	2017 (N=20395)
SEP					
AB (N=18966) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=25570)	**1·36* (1·11-1·68)**	**1·38* (1·12-1·71)**	**1·47** (1·20-1·80)**	**1·43** (1·19-1·72)**	**1·36** (1·14-1·64)**
C2 (N=16193)	**1·66*** (1·34-2·07)**	**1·69*** (1·36-2·10)**	**1·78*** (1·45-2·21)**	**1·77*** (1·46-2·15)**	**1·78*** (1·47-2·17)**
D (N=11958)	**1·45* (1·14-1·84)**	**1·48* (1·16-1·88)**	**2·17*** (1·74-2·69)**	**1·77*** (1·43-2·19)**	**1·70*** (1·37-2·12)**
E (N=8370)	**2·23*** (1·75-2·84)**	**2·28*** (1·78-2·91)**	**2·12*** (1·68-2·67)**	**1·84*** (1·45-2·32)**	**2·61*** (2·08-3·28)**
Age					
16-24 (N=12453) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
25-34 (N=11951)	**1·48*** (1·33-1·64)**	**1·58*** (1·27-1·96)**	**1·47** (1·20-1·81)**	**1·30 (1·06-1·60)**	**1·59*** (1·28-1·98)**
35-44 (N=11618)	**1·41*** (1·27-1·57)**	**1·51** (1·20-1·88)**	**1·37* (1·11-1·69)**	**1·27 (1·03-1·56)**	**1·53** (1·23-1·90)**
45-54 (N=12142)	**1·37*** (1·24-1·53)**	**1·46** (1·18-1·82)**	**1·45** (1·18-1·79)**	1·20 (0·98-1·47)	**1·42* (1·14-1·77)**
55-64 (N=12522)	0·96 (0·86-1·07)	0·95 (0·74-1·20)	1·01 (0·81-1·26)	0·86 (0·69-1·06)	1·03 (0·82-1·29)
65+ (N=20371)	**0·39*** (0·35-0·44)**	**0·48*** (0·37-0·62)**	**0·36*** (0·28-0·46)**	**0·35*** (0·28-0·45)**	**0·40*** (0·31-0·51)**
Region					
London (N=14252) ref	1·00	1·00	1·00	1·00	1·00
North East (N=4099)	**2·39*** (2·05-2·79)**	**2·30*** (1·66-3·15)**	**2·73** (2·01-3·67)**	**2·85*** (2·10-3·85)**	**1·84** (1·34-2·51)**
North West (N=11652)	**2·66*** (2·37-2·99)**	**2·74*** (2·13-3·55)**	**2·82** (2·26-3·52)**	**2·99*** (2·38-3·79)**	**2·13*** (1·69-2·70)**

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Table 3.2 continued: Associations between e-cigarette use and SEP among all adults in England 2014-2017

	Overall (N=81057)	2014 (N=20192)	2015 (N=20034)	2016 (N=20436)	2017 (N=20395)
Region					
Yorkshire&Humber (N=9136)	**2·52*** (2·23-2·86)**	**2·66*** (2·05-3·46)**	**2·51** (1·99-3·18)**	**2·69*** (2·09-3·46)**	**2·28*** (1·78-2·92)**
East Midlands (N=6543)	**1·70*** (1·46-1·96)**	**2·08*** (1·51-2·85)**	**1·70** (1·29-2·23)**	**1·58* (1·17-2·13)**	**1·49* (1·13-1·98)**
West Midlands (N=9126)	**1·36*** (1·18-1·57)**	**1·46 (1·08-1·97)**	1·20 (0·91-1·58)	**1·75*** (1·34-2·28)**	1·09 (0·81-1·45)
East of England (N=8191)	**1·89*** (1·61-2·13)**	**1·89*** (1·41-2·54)**	**2·05** (1·55-2·70)**	**2·06*** (1·56-2·71)**	**1·50* (1·15-1·96)**
South East (N=10241)	**1·91*** (1·67-2·18)**	**2·04*** (1·54-2·71)**	**1·99** (1·52-2·61)**	**2·02*** (1·56-2·63)**	**1·61** (1·26-2·07)**
South West (N=7728)	**2·32*** (2·02-2·65**	**2·99*** (2·27-3·94)**	**2·21** (1·67-2·92)**	**2·52*** (1·93-3·30)**	**1·71*** (1·31-2·23)**
Sex					
Men (N=40978) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
Women (N=40061)	**0·85*** (0·80-0·90)**	0·95 (0·84-1·09)	0·91 (0·80-1·02)	**0·76*** (0·67-0·86)**	**0·79** (0·70-0·90)**
Survey Year					
2014 (N=20192) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
2015 (N=20034)	1·05 (0·83-1·33)				
2016 (N=20436)	1·14 (0·91-1·43)				
2017 (N=20395)	1·11 (0·89-1·39)				

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Table 3.2 continued: Associations between e-cigarette use and SEP among all adults in England 2014-2017

	Overall (N=81057)	2014 (N=20192)	2015 (N=20034)	2016 (N=20436)	2017 (N=20395)
Interaction terms					
C1*2015	1·08 (0·81-1·44)				
C2*2015	1·07 (0·79-1·44)				
D*2015	**1·48 (1·07-2·03)**				
E*2015	0·95 (0·68-1·32)				
C1*2016	1·05 (0·80-1·39)				
C2*2016	1·07 (0·80-1·43)				
D*2016	1·23 (0·90-1·69)				
E*2016	0·85 (0·60-1·18)				
C1*2017	1·00 (0·76-1·31)				
C2*2017	1·07 (0·80-1·43)				
D*2017	1·18 (0·85-1·62)				
E*2017	1·16 (0·83-1·60)				

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Past-year smokers

A socio-economic gradient was evident in prevalence of e-cigarette use among past-year smokers for the overall time period. However, the gradient ran in the opposite direction with significantly lower odds of use by social grades C2, D and E compared with AB (Table 3.3). There was no time trend across all social grades and no clear interaction between social grade and time. The exception again was that prevalence in social grade D compared with AB depended on year, with higher comparative prevalence in 2015 compared with 2014 (Table 3.3 and Figure 3.2b). When the analysis was stratified by year, prevalence across the social gradient was largely similar by 2017.

Table 3.3: Associations between e-cigarette use and SEP among past-year smokers in England 2014-2017

	Overall (N=16104)	2014 (N=4252)	2015 (N=4201)	2016 (N=3967)	2017 (N=3684)
SEP					
AB (N=2036) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=4437)	0·83 (0·64-1·07)	0·83 (0·65-1·08)	0·90 (0·70-1·16)	0·96 (0·75-1·23)	0·88 (0·68-1·13)
C2 (N=3712)	**0·70*** **(0·54-0·91)**	**0·70*** **(0·54-0·91)**	**0·72** **(0·56-0·94)**	0·92 (0·72-1·19)	0·91 (0·69-1·19)
D (N=3144)	**0·53***** **(0·40-0·71)**	**0·53***** **(0·49-0·70)**	0·85 (0·66-1·11)	**0·70** **(0·53-0·93)**	**0·71** **(0·53-0·96)**
E (N=2775)	**0·67*** **(0·50-0·89)**	**0·67*** **(0·50-0·89)**	**0·57***** **(0·43-0·75)**	**0·64*** **(0·48-0·85)**	0·91 (0·68-1·22)
Age					
16-24 (N=3100) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
25-34 (N=3187)	**1·14** **(1·00-1·29)**	**1·30** **(1·01-1·66)**	1·19 (0·94-1·51)	1·01 (0·79-1·29)	1·07 (0·82-1·40)
35-44 (N=2604)	**1·23*** **(1·08-1·39)**	**1·38** **(1·07-1·78)**	1·22 (0·95-1·57)	1·04 (0·80-1·34)	1·28 (0·97-1·68)
45-54 (N=2716)	**1·22*** **(1·08-1·39)**	**1·43*** **(1·11-1·84)**	**1·42*** **(1·11-1·80)**	0·97 (0·76-1·25)	1·10 (0·84-1·45)
55-64 (N=2330)	1·05 (0·92-1·20)	1·07 (0·81-1·42)	1·22 (0·94-1·57)	0·90 (0·69-1·18)	0·99 (0·74-1·32)
65+ (N=2167)	**0·70***** **(0·60-0·81)**	0·95 (0·71-1·27)	**0·62*** **(0·46-0·84)**	**0·57**** **(0·43-0·76)**	**0·68** **(0·50-0·93)**
Region					
London (N=2495) ref	1·00	1·00	1·00	1·00	1·00
North East (N=998)	**1·75***** **(1·45-2·11)**	**1·58** **(1·10-2·27)**	**1·69*** **(1·16-2·43)**	**1·95**** **(1·33-2·83)**	**1·87*** **(1·24-2·80)**
North West (N=2660)	**1·82***** **(1·57-2·09)**	**1·92***** **(1·43-2·60)**	**1·74***** **(1·34-2·26)**	**1·92***** **(1·45-2·56)**	**1·68*** **(1·23-2·31)**

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Table 3.3 continued: Associations between e-cigarette use and SEP among past-year smokers in England 2014-2017

	Overall (N=16104)	2014 (N=4252)	2015 (N=4201)	2016 (N=3967)	2017 (N=3684)
Region					
Yorkshire&Humber (N=2102)	**2·00*** (1·72-2·32)**	**1·75** (1·30-2·36)**	**1·85*** (1·41-2·44)**	**2·35*** (1·73-3·19)**	**2·29*** (1·65-3·17)**
East Midlands (N=1319)	**1·48*** (1·23-1·76)**	**1·91** (1·32-2·75)**	1·28 (0·93-1·76)	**1·47 (1·01-2·12)**	1·35 (0·93-1·96)
West Midlands (N=1710)	**1·24 (1·05-1·47)**	1·39 (0·99-1·96)	1·03 (0·75-1·42)	**1·51 (1·09-2·08)**	1·02 (0·70-1·49)
East of England (N=1450)	**1·58*** (1·33-1·87)**	**1·43 (1·01-2·01)**	**1·60* (1·14-2·24)**	**1·58* (1·13-2·21)**	**1·74* (1·23-2·45)**
South East (N=1792)	**1·48*** (1·26-1·74)**	**1·44 (1·04-1·99)**	1·37 (0·99-1·90)	**1·59* (1·16-2·20)**	**1·52 (1·10-2·12)**
South West (N=1564)	**1·68*** (1·42-1·98)**	**2·16*** (1·57-2·97)**	**1·41 (1·01-1·96)**	**1·56* (1·13-2·16)**	**1·61* (1·13-2·30)**
Sex					
Men (N=8595) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
Women (N=7509)	1·04 (0·96-1·13)	**1·20 (1·03-1·40)**	1·12 (0·96-1·30)	0·91 (0·78-1·06)	0·95 (0·81-1·12)
Survey Year					
2014 (N=4252) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
2015 (N=4201)	1·01 (0·76-1·36)				
2016 (N=3967)	0·94 (0·70-1·26)				
2017 (N=16104)	0·85 (0·63-1·14)				

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Table 3.3 continued: Associations between e-cigarette use and SEP among past-year smokers in England 2014-2017

	Overall (N=16104)	2014 (N=4252)	2015 (N=4201)	2016 (N=3967)	2017 (N=3684)
Interaction terms					
C1*2015	1·10 (0·77-1·57)				
C2*2015	1·04 (0·72-1·50)				
D*2015	**1·60 (1·09-2·34)**				
E*2015	0·86 (0·58-1·27)				
C1*2016	1·17 (0·82-1·66)				
C2*2016	1·34 (0·93-1·92)				
D*2016	1·35 (0·91-2·00)				
E*2016	0·96 (0·64-1·43)				
C1*2017	1·06 (0·74-1·51)				
C2*2017	1·29 (0·89-1·88)				
D*2017	1·33 (0·89-1·99)				
E*2017	1·36 (0·90-2·03)				

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

During a quit attempt among smokers attempting to quit

There were no significant associations across the overall period between all social grades and prevalence of e-cigarette use among smokers making a quit attempt (Table 3.4). There was no time trend across all social grades and little interaction between social grade and time. However, as with past-year smokers, prevalence in social grade D compared with AB depended on year, with higher comparative prevalence in 2015 compared with 2014 (Table 3.4 and Figure 3.2c). When the analysis was stratified by year, there were no significant associations between all social grades and prevalence of e-cigarette use in each year.

Table 3.4: Associations between e-cigarette use during a quit attempt and SEP among smokers attempting to quit in England 2014-2017

	Overall (N=5176)	2014 (N=1503)	2015 (N=1305)	2016 (N=1156)	2017 (N=1212)
SEP					
AB (N=748) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=1501)	0·89 (0·61-1·31)	0·89 (0·60-1·31)	1·03 (0·70-1·52)	0·71 (0·48-1·04)	1·08 (0·73-1·59)
C2 (N=1178)	0·91 (0·62-1·35)	0·89 (0·60-1·32)	1·03 (0·69-1·56)	1·19 (0·81-1·75)	1·30 (0·87-1·95)
D (N=911)	0·76 0·50-1·16)	0·77 (0·50-1·17)	1·36 (0·90-2·05)	0·74 (0·48-1·15)	1·40 (0·91-2·16)
E (N=838)	0·76 (0·50-1·17)	0·76 (0·49-1·18)	0·73 (0·47-1·13)	0·85 (0·54-1·32)	0·95 (0·61-1·49)
Age					
16-24 (N=1049) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
25-34 (N=1185)	1·06 (0·88-1·27)	0·87 (0·61-1·23)	1·02 (0·72-1·46)	1·36 (0·94-1·97)	1·07 (0·73-1·55)
35-44 (N=932)	1·15 (0·95-1·39)	1·31 (0·92-1·86)	0·99 (0·67-1·46)	1·16 (0·77-1·72)	1·06 (0·72-1·58)
45-54 (N=845)	1·03 (0·85-1·25)	0·87 (0·59-1·28)	1·30 (0·88-1·91)	1·00 (0·66-1·51)	0·95 (0·64-1·43)
55-64 (N=667)	1·02 (0·83-1·26)	1·07 (0·71-0·60)	1·07 (0·70-1·62)	1·18 (0·77-1·82)	0·79 (0·51-1·23)
65+ (N=498)	**0·64**** **(0·50-0·81)**	**0·51*** **(0·31-0·82)**	0·76 (0·46-1·22)	0·98 (0·59-1·61)	**0·44*** **(0·26-0·73)**
Region					
London (N=782) ref	1·00	1·00	1·00	1·00	1·00
North East (N=324)	**2·45***** **(1·84-3·28)**	**2·24*** **(1·29-3·92)**	**4·05***** **(2·18-7·54)**	**3·19**** **(1·73-5·91)**	1·53 (0·84-2·75)

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Table 3.4 continued: Associations between e-cigarette use during a quit attempt and SEP among smokers attempting to quit in England 2014-2017

	Overall (N=5176)	2014 (N=1503)	2015 (N=1305)	2016 (N=1156)	2017 (N=1212)
Region					
North West (N=864)	**2·23*** (1·79-2·80)**	**2·72*** (1·69-4·47)**	**2·42*** (1·59-3·74)**	**2·43** (1·52-3·93)**	**1·61 (1·02-2·52)**
Yorkshire&Humber (N=697)	**2·65*** (2·10-3·35)**	**2·92*** (1·82-4·78)**	**3·19*** (2·03-5·06)**	**2·83*** (1·75-4·64)**	**1·89* (1·17-3·06)**
East Midlands (N=355)	**2·24*** (1·69-2·97)**	**2·56* (1·42-4·64)**	**2·50** (1·49-4·18)**	**2·96** (1·57-5·59)**	1·38 (0·78-2·43)
West Midlands (N=499)	**1·90*** (1·47-2·46)**	**2·10* (1·22-3·65)**	**2·19* (1·31-3·68)**	**2·87*** (1·70-4·89)**	1·00 (0·59-1·67)
East of England (N=557)	**2·16*** (1·69-2·78)**	**2·01 (1·17-3·47)**	**3·06*** (1·87-5·05)**	**1·96 (1·17-3·30)**	**1·89* (1·19-3·03)**
South East (N=570)	**2·02*** (1·57-2·59)**	**2·55** (1·51-4·35)**	**2·52** (1·49-4·26)**	**2·24* (1·33-3·81)**	1·26 (0·80-1·98)
South West (N=523)	**2·18*** (1·70-2·82)**	**2·89*** (1·72-4·92)**	**2·81*** (1·67-4·73)**	**2·28* (1·37-3·81)**	1·22 (0·73-2·02)
Sex					
Men (N=2638) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
Women (N=2538)	1·03 (0·91-1·16)	1·08 (0·86-1·36)	1·11 (0·87-1·41)	0·90 (0·70-1·16)	1·01 (0·79-1·29)
Survey Year					
2014 (N=1503) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
2015 (N=1305)	1·08 (0·69-1·70)				
2016 (N=1156)	1·38 (0·90-2·13)				
2017 (N=1212)	1·04 (0·67-1·63)				

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Table 3.4 continued: Associations between e-cigarette use during a quit attempt and SEP among smokers attempting to quit in England 2014-2017

	Overall (N=5176)	2014 (N=1503)	2015 (N=1305)	2016 (N=1156)	2017 (N=1212)
Interaction terms					
C1*2015	1·17 (0·68-2·01)				
C2*2015	1·18 (0·67-2·06)				
D*2015	**1·80 (1·01-3·21)**				
E*2015	1·01 (0·55-1·84)				
C1*2016	0·79 (0·46-1·34)				
C2*2016	1·35 (0·78-2·14)				
D*2016	0·99 (0·54-1·79)				
E*2016	1·15 (0·62-2·11)				
C1*2017	1·18 (0·69-2·03)				
C2*2017	1·41 (0·81-2·47)				
D*2017	1·75 (0·97-3·18)				
E*2017	1·22 (0·66-2·25)				

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Long-term ex-smokers

Across the overall time-period, a socio-economic gradient in the prevalence of e-cigarette use was evident among long term ex-smokers. Respondents from social grades C2 and D had twice the odds of using e-cigarettes compared with AB (Table 3.5). A time trend was evident whereby in 2016 and 2017 respondents from all social grades were much more likely to use e-cigarettes than in 2014 (Table 3.5 and Figure 3.2d). There were no interactions between social grade and time. When the analysis was stratified by year, respondents from social grades C2-E in 2015 were each almost three times as likely to use e-cigarettes compared with those from AB. Trends across all social grades were similar among long-term ex-smokers, with e-cigarette use increasing from 2014 to 2017 (Figure 3.2d).

Table 3.5: Associations between e-cigarette use and SEP among long term ex-smokers in England 2014-2017

	Overall (N=13782)	2014 (N=3170)	2015 (N=3462)	2016 (N=3533)	2017 (N=3617)
SEP					
AB (N=3952) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=4301)	1·38 (0·74-2·66)	1·37 (0·74-2·67)	**1·77** **(1·05-3·08)**	1·23 (0·84-1·81)	1·28 (0·91-1·81)
C2 (N=2886)	**2·03** **(1·08-3·96)**	**2·07** **(1·10-4·06)**	**2·83**** **(1·66-4·97)**	1·27 (0·83-1·95)	**1·50** **(1·03-2·19)**
D (N=1541)	**2·29** **(1·13-4·70)**	**2·35** **(1·15-4·86)**	**2·92**** **(1·57-5·48)**	**2·14**** **(1·36-3·35)**	1·34 (0·85-2·10)
E (N=1102)	1·14 (0·37-3·03)	1·14 (0·36-3·06)	**2·87*** **(1·48-5·56)**	0·81 (0·38-1·58)	**1·90** **(1·14-3·07)**
Age					
16-24 (N=368) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
25-34 (N=1060)	1·26 (0·87-1·85)	1·45 (0·58-4·12)	1·21 (0·57-2·86)	1·19 (0·60-2·52)	1·25 (0·67-2·43)
35-44 (N=1562)	0·97 (0·67-1·42)	0·90 (0·36-2·60)	1·05 (0·50-2·42)	1·01 (0·51-2·12)	0·91 (0·49-1·76)
45-54 (N=1970)	0·82 (0·57-1·20)	0·78 (0·32-2·23)	0·71 (0·33-1·66)	0·94 (0·49-1·95)	0·79 (0·43-1·52)
55-64 (N=2683)	**0·44***** **(0·30-0·64)**	0·50 (0·20-1·43)	**0·29*** **(0·13-0·71)**	**0·44** **(0·22-0·92)**	**0·50** **(0·27-0·95)**
65+ (N=6139)	**0·14***** **(0·10-0·21)**	**0·17**** **(0·07-0·49)**	**0·12***** **(0·06-0·30)**	**0·14***** **(0·07-0·30)**	**0·14***** **(0·08-0·28)**
Region					
London (N=1237) ref	1·00	1·00	1·00	1·00	1·00
North East (N=911)	**1·71*** **(1·14-2·54)**	0·79 (0·23-2·53)	**3·24*** **(1·41-7·74)**	**2·17** **(1·02-4·80)**	1·30 (0·67-2·49)

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Table 3.5 continued: Associations between e-cigarette use and SEP among long term ex-smokers in England 2014-2017

	Overall (N=13782)	2014 (N=3170)	2015 (N=3462)	2016 (N=3533)	2017 (N=3617)
Region					
North West (N=1976)	**2·92*** (2·13-4·05)**	**2·94 (1·30-7·53)**	**4·06** (2·06-8·75)**	**3·29** (1·77-6·63)**	**2·24* (1·38-3·74)**
Yorkshire&Humber (N=1496)	**1·58 (1·11-2·28)**	1·11 (0·40-3·20)	1·99 (0·92-4·53)	1·65 (0·81-3·53)	1·59 (0·91-2·80)
East Midlands (N=1056)	1·41 (0·95-2·09)	1·11 (0·34-3·45)	1·05 (0·39-2·74)	1·38 (0·62-3·11)	1·77 (0·98-3·19)
West Midlands (N=1413)	1·16 (0·79-1·71)	0·66 (0·21-2·04)	1·30 (0·53-3·20)	**2·09 (1·01-4·51)**	0·86 (0·46-1·59)
East of England (N=1509)	1·30 (0·90-1·91)	1·33 (0·49-3·76)	1·86 (0·82-4·41)	1·85 (0·88-4·05)	0·83 (0·65-1·90)
South East (N=2449)	1·19 (0·84-1·69)	0·97 (0·39-2·66)	1·41 (0·63-3·32)	1·32 (0·67-2·78)	1·10 (0·65-1·90)
South West (N=1715)	**1·52 (1·07-2·19)**	1·31 (0·52-3·56)	1·86 (0·79-4·50)	1·69 (0·84-3·58)	1·37 (0·79-2·41)
Sex					
Men (N=7778) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
Women (N=6004)	0·89 (0·76-1·04)	1·08 (0·71-1·65)	0·85 (0·61-1·20)	0·81 (0·61-1·08)	0·90 (0·69-1·17)
Survey Year					
2014 (N=3170) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
2015 (N=3462)	1·09 (0·56-2·19)				
2016 (N=3533)	**2·58* (1·47-4·80)**				
2017 (N=3617)	**3·07** (1·78-5·66)**				

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Table 3.5 continued: Associations between e-cigarette use and SEP among long term ex-smokers in England 2014-2017

	Overall (N=13782)	2014 (N=3170)	2015 (N=3462)	2016 (N=3533)	2017 (N=3617)
Interaction terms					
C1*2015	1·29 (0·56-2·93)				
C2*2015	1·36 (0·58-3·14)				
D*2015	1·28 (0·50-3·27)				
E*2015	2·53 (0·78-9·23)				
C1*2016	0·87 (0·41-1·81)				
C2*2016	0·62 (0·29-1·33)				
D*2016	0·92 (0·40-2·12)				
E*2016	0·71 (0·21-2·64)				
C1*2017	0·93 (0·44-1·88)				
C2*2017	0·75 (0·35-1·57)				
D*2017	0·59 (0·25-1·36)				
E*2017	1·67 (0·56-5·72)				

Ns are not weighted. Results for prevlance of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. <0·05 p values are indicated in bold· *p<0·01, **p<0·001, ***p<0.0001.

Sensitivity analyses

Housing tenure was used as an alternative measure of SEP and yielded a similar pattern of results compared with the main analysis (Table 2.6).

All adults

Among all adults, respondents of social housing tenure had twice the odds of using an e-cigarette overall and in each year 2014 to 2017.

Past year smokers

There were no differences in prevalence of e-cigarette use between tenure groups among past-year smokers, except that when stratified by year, respondents in 2017 from social housing were significantly more likely to use an e-cigarette.

During a quit attempt among smokers attempting to quit

There were no significant differences in e-cigarette use during a quit attempt among smokers attempting to quit, both overall and in each year.

Long-term ex-smokers

Among long-term ex-smokers, social housing respondents had twice the odds of using an e-cigarette (OR=2·26, 95% CI 1·40-3·57, p=0·0006); however, when stratified by year the associations were weaker and non-significant in 2016 and 2017.

Table 3.6: Associations between e-cigarette use and housing tenure among specified smoker and ex-smoker subgroups in England 2014-2017.

	Overall	2014	2015	2016	2017
Housing Tenure					
Other ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
Social Housing					
All adults (N=13892)	**2·11*** (1·82-2·44)**	**2·09*** (1·80-2·42)**	**1·95*** (1·69-2·24)**	**1·88*** (1·63-2·18)**	**2·16*** (1·87-2·48)**
Past year smokers (N=4799)	0·98 (0·83-1·16)	0·95 (0·80-1·12)	0·94 (0·79-1·10)	0·98 (0·82-1·16)	**1·20 (1·00-1·43)**
Quit attempters (N=1589)	0·96 (0·75-1·22)	0·97 (0·76-1·25)	1·06 (0·82-1·37)	1·20 (0·91-1·58)	1·27 (0·99-1·65)
Long term ex-Smokers (N=2013)	**2·26** (1·40-3·57)**	**2·31** (1·41-3·68)**	**1·99** (1·34-2·93)**	1·27 (0·84-1·85)	1·24 (0·88-1·72)

Ns are not weighted. Results for prevlance of e-cigarette use are presented as ORs (95% CI) against the indicated referent. <0·05 p values are indicated in bold. *p<0·01, **p<0·001, ***p<0.0001. Housing tenure classification comprises the collapsed groups ‘Social housing’ (local authority or housing association) and ‘Other’ (mortgage bought, owned outright, private renting and other).

Daily e-cigarette use

In further sensitivity analyses, current e-cigarette use was redefined as those respondents reporting i) daily or ii) at least weekly e-cigarette use. Consistent with the main analysis, a social gradient in prevalence of daily use among all adults was evident whereby odds of using e-cigarettes were significantly higher for respondents from lower social grades (Appendix 5 Table A5.1). The pattern in daily e-cigarette use among past-year smokers, although less pronounced, corresponded to the main analysis wherein respondents from lower social grades has lower odds of using an e-cigarette (Appendix 5 Table A5.2). Daily use of e-cigarettes among those who made a recent quit attempt followed no obvious socio-economic or temporal pattern (Appendix Table 5 A5.3). Long term ex-smokers from lower social grades had higher odds of daily e-cigarette use compared with those from AB (Appendix 5 Table A5.4). As for the main analysis the odds of daily e-cigarette use among long-term ex-smokers across all social grades were greater in 2016 and 2017 compared with 2014.

Weekly e-cigarette use

I also re-defined current use to at least weekly use. Overall prevalence of e-cigarette use among all adults also ran along a social gradient with respondents from lower social grades having greater odds of e-cigarette use (Appendix 5 Table A5.5). When the analysis was stratified by year, these differences were largely absent by 2017. Among past-year smokers no clear pattern in weekly e-cigarette use was evident overall, although when stratified by year respondents from lower social grades had lower odds of use in 2017 (Appendix 5 Table A5.6). No significant differences in prevalence of weekly e-cigarette use between social grades were present among smokers attempting to quit (Appendix Table 5 A5.7) and long-term ex-smokers (Appendix 5 Table A5.8), with the exception of greater use among group D in 2017.

3.4 Discussion

From 2014 to 2017 in England, e-cigarette use was greater among socio-economically disadvantaged adults compared with more advantaged adults. This socio-economic gradient in e-cigarette use is a reflection of the higher rates of smoking among the lower SEP population, and the higher prevalence of e-cigarette use among smokers.[131,165] A socio-economic gradient in e-cigarette use was also evident within past-year smokers but ran in the opposite direction with e-cigarette use more prevalent among more advantaged respondents. This gradient within past-year smokers converged over time whereby use appeared similar across the socio-economic spectrum by 2017. There were no significant differences in e-cigarette use during a quit attempt by SEP throughout the entire time period. The use of e-cigarettes by long-term ex-smokers increased over time among all respondents but was consistently more prevalent in ex-smokers from of more disadvantaged SEP.

In this current study, the socio-economic gradient evident in the use of e-cigarettes by past-year smokers between 2014 and 2017 is in agreement with previous research, which found that among current smokers, e-cigarette use was associated with more advantaged SEP.[165] However, an important finding from this current study is that there was evidence of convergence such that by 2017 socio-economic differences in e-cigarette use were no longer evident among past-year smokers. In England there has been no overall reduction in tobacco smoking inequalities in recent years[26,120], and it is therefore unlikely that this has had an impact on the observed attenuation of differences in e-cigarette use across the socio-economic spectrum. If this observed convergence continues to be evident in the coming years, it suggests that the distribution in current use of e-cigarettes by past-year smokers is unlikely to have a persistent impact on heath inequalities. However, if overall adoption of e-cigarettes increases among lower SEP groups in future then this could potentially displace some cigarette smoking and lead to greater reductions in cigarette consumption as a result.

E-cigarette use during a quit attempt was similar across SEP groups throughout the four-year period from 2014-2017 suggesting that e-cigarette use in this group will not widen health inequalities. Had differences in use been observed then it may have had important implications for health inequalities considering that analyses using STS data found that changes in the overall use of e-cigarettes in England was positively associated with the success rates of quit attempts.[140] A separate study using STS data investigated moderators of real-world effectiveness of smoking cessation aids in England and found that there was no association between e-cigarette use and SEP.[250] This absence of a difference in quit-attempt effectiveness by SEP makes it unlikely that the devices will act to either reduce or exacerbate existing inequalities in smoking cessation. However, similar to the observations made above regarding past year smokers, if overall adoption of e-cigarettes in a quit attempt increases among lower SEP groups in future then it may lead to higher smoking cessation rates. Possible trends of this nature will continue to be investigated going forward.

Among long-term ex-smokers, lower SEP respondents were more likely to use e-cigarettes compared with the most advantaged respondents. A probable explanation for this socio-economic gradient is that long-term ex-smokers from more advantaged socio-economic groups are using e-cigarettes either during a quit attempt or following smoking cessation, but are then discontinuing their use, whereas long-term ex-smokers from more disadvantaged groups continue to use e-cigarettes after a successful quit attempt. This hypothesis is supported by qualitative research among stop-smoking practitioners, who thought that socio-economically disadvantaged smokers were more likely to develop a lifestyle of e-cigarette use in the long-term.[251] Use across all socio-economic groups increased significantly between 2014 and 2017 and the increase was greatest among those of more disadvantaged SEP, which may reflect the popularity of e-cigarettes as an aid for smoking cessation. However, given that e-cigarette use is plateauing among recent ex-smokers[165], this increasing trend among long-term ex-smokers may level out in future.

Recent research conducted using US National Health Interview Survey data has suggested that between 2014-2016 more educated smokers were more likely to transition to exclusive e-cigarette use compared with less educated smokers.[169] Interestingly, this study did not report the same association among higher income smokers. However, research using data from the Population Assessment of Tobacco and Health (PATH) study has suggested that exclusive e-cigarette use was more likely among higher-income and White (compared with non-Hispanic Black or Hispanic) smokers.[170] In contrast, this current study using STS data found that lower SEP long-term ex-smokers in England were more likely to use e-cigarettes compared with more socio-economically advantaged groups. It is possible that the more favourable health policy and advocacy environment towards e-cigarettes in England compared with that in the US has influenced this apparent difference. However, such comparisons are made with caution, given that the two countries have different social and demographic contexts and because the study sub-groups were defined differently. For instance, exclusive use in the US study likely included a considerable proportion of ex-smokers who had stopped within the past year.
The impact that the socio-economic gradient observed in this study will have on inequalities depends on whether e-cigarette use by long-term ex-smokers effectively protects ex-smokers against relapse to tobacco smoking, for which there is currently an absence of evidence. Insofar as it is protective, it is likely to have a positive effect on inequalities. Insofar that it has little impact on long-term relapse, it may exacerbate inequalities because the use of e-cigarettes while safer than smoking tobacco, is not without risk.[123]

A major strength of this study is that it used a large representative sample of the population in England. Another strength is the use of housing tenure as an alternative indicator of SEP in a sensitivity analysis which provided convergent results. However, as is common with this type of analysis, the results are limited by the use of cross-sectional survey data, where smoking status was self-reported by respondents and not biochemically verified. Past e-cigarette use was not included as an outcome because the STS does not currently collect data to this end and only current and recent (<12 month) use in a quit attempt were assessed. Lastly, it is also difficult to measure e-cigarette consumption levels accurately since no validated quantifiable measure is currently available.[252] However, to account for this sensitivity analyses using daily and at-least weekly measures of 'current' e-cigarette use were conducted, which largely confirmed findings from the main analyses. However, it should be noted that in the sensitivity analyses for the past-year quit attempter subgroup, daily or weekly e-cigarette use reflects current use at the time of the survey, and not current use during the most recent quit attempt.

3.5 Conclusion

In conclusion, this study found that from 2014 to 2017 in England, overall e-cigarette use was more prevalent among higher-SEP compared with lower SEP smokers, but that this difference attenuated over time. E-cigarette use specifically during a quit attempt was similar across SEP groups throughout the period. Among long-term ex-smokers a social gradient was also evident with e-cigarette use consistently more likely among lower SEP groups, and use increased across all groups since 2014. Sensitivity analyses using different measures of SEP and frequency of e-cigarette use produced largely concordant results. Socio-economic disparities in e-cigarette use should continue to be monitored in order to understand differences in use across the social gradient, and to promote future interventions involving e-cigarettes to reduce existing health inequalities. Understanding e-cigarette usage trends by SEP is necessary in the context of the continuous evolution of e-cigarette technologies, variable media coverage and changing positions of different health and medical bodies.

Results from this study indicated that continued surveillance of long-term ex-smokers as a specific sub-group is important and appears to show significant socio-economic patterning. Further monitoring of this group will clarify whether e-cigarette use among long-term ex-smokers is indeed levelling-off, and if there are different trends according to SEP. In addition, by subgrouping individuals according to whether they started using an e-cigarette only after they had quit smoking as opposed to those who use the devices during a quit attempt and continue to use them afterwards, it is possible elucidate which sub-group of long-term ex-smokers is driving potential increases in usage. This interrogation of the long-term ex-smoker sub-group is the subject of the next study, outlined in Chapter 4.

Chapter 4

Association between socio-economic position and e-cigarette use among past-year and long-term ex-smokers in England 2014-2019 (Study 3)

Reference for publication (full paper in Appendix 3): Kock, L., Brown, J. and Shahab, L. 2020. Association of socio-economic position with e-cigarette use among individuals who quit smoking in England, 2014 to 2019. *JAMA Netw Open*, *3*(6).

Abstract

E-cigarette use among ex-smokers differs according to socio-economic position (SEP), which may impact on smoking-related health inequalities depending on whether the devices protect against relapse to tobacco smoking. This study aimed to assess trends in current e-cigarette use by SEP among i) all long-term (>1-year) ex-smokers and, to distinguish recent and late post-cessation uptake, respectively, ii) among past-year ex-smokers who did not use an e-cigarette in their most recent quit attempt (representing recent uptake), and iii) long-term ex-smokers who quit smoking before e-cigarettes became popular in 2011 (representing late uptake). Participants included adult (16+) respondents in the Smoking Toolkit Study. Data were collected between January 2014 and September 2019.

The outcome measure for the analyses was current e-cigarette use. Social grade based on occupation was operationalised as the explanatory variable for SEP, using the National Readership Survey classification system of ABC1 (higher and intermediate managerial,

administrative and professional, supervisory, clerical and junior managerial, administrative and professional) and C2DE (skilled, semi-skilled and unskilled manual workers, state pensioners, casual and lowest-grade workers, unemployed with state benefits only). The analyses were stratified by year to assess the changes in these associations over time.

Among long-term ex-smokers (N = 19,297), use of e-cigarettes increased from 3.3% in 2014 to 10.4% in 2019 among all groups (odds ratio (OR)=3.46, 95% confidence interval = 2.45–4.97). Use was more common across the period among long-term ex-smokers from SEP group C2DE (OR=1.59, 1.05–2.40) compared with ABC1. Regarding post-cessation uptake of e-cigarettes, there was no clear trend over time, or any apparent difference according to SEP, with 7.1% e-cigarette use among past-year ex-smokers who did not use an e-cigarette in their most recent quit attempt (n=904). Among pre-2011 long-term ex-smokers (n=14,241), the significant increase over time in use of e- cigarettes was also similar across SEP (0.8% in 2014 to 2.1% in 2019) (compared with 2014, 2018: OR=2.79, 1.37–6.13; 2019: OR = 3.22, 1.56-7.40).

From 2014 to 2019 among long-term ex-smokers, e-cigarette use is more common among those who are more disadvantaged and most probably reflects continued use of e-cigarettes as a long-term cessation aid in those of more disadvantaged SEP. Continued monitoring of this socio-economic patterning is important. Equity positive or negative impacts of this usage will likely depend upon whether e-cigarettes confer the public health benefit of protection against long-term relapse to smoking. Late, but not recent, post-cessation uptake of e-cigarettes increased over time but is not likely to impact on smoking-related health inequalities because there were no differences by SEP.

4.1 Background

E-cigarettes continue to be the most popular quitting aid in England[131] (Chapter 1), with growing evidence and support for the devices as an effective method for smoking cessation.[138,140] Although not risk-free, the devices are generally thought to confer substantially lower levels of harm to users compared with combusted tobacco.[122,123] Switching smokers on to harm-reduced nicotine products continues to be a public health policy focus in England[121], and as smoking rates decline it remains important to monitor trends in e-cigarette use at the population-level.[26] E-cigarette use among never smokers remains negligible in England, but interrogating usage patterns among the growing number of ex-smokers that use e-cigarettes[253] is important because as outlined in Chapter 3 it is not yet clear whether or not the devices protect against relapse to smoking in the longer term. Until such evidence emerges, it is important to monitor use by long-term ex-smokers because without the benefit of protecting against relapse to smoking the long-term use of an e-cigarette is likely to be harmful. There are several possible trajectories of use among ex-smokers. Users may initiate e-cigarette use before or during a quit attempt and continue to use them in the longer-term once they have quit.[140,254] Alternatively, as will be investigated in this current study, e-cigarette uptake may occur among ex-smokers who did not use an e-cigarette in their quit attempt. This uptake may occur within a year of quitting, or in the longer-term.

Research in the USA using National Health Interview Survey data indicated that smokers with higher education were more likely to transition to exclusive e-cigarette use compared with less educated smokers.[169] Also in the USA, recent Population Assessment of Tobacco and Health (PATH) study data have shown that exclusive e-cigarette use was more likely among higher-income smokers.[170] These findings contrast with the current evidence on e-cigarette use in the UK. In England specifically there are no apparent differences in e-cigarette use during a quit attempt between smokers of different socio-economic position (SEP), and as the previous study (Chapter 3) suggested, a social gradient in use by long-term (>1-year) ex-smokers exists such that there appears to be greater use among those of more disadvantaged SEP.[253,255] It is therefore possible that ex-smokers of more advantaged SEP are using e-cigarettes during a quit attempt before discontinuing their use. In contrast, a greater proportion of disadvantaged SEP ex-smokers may continue to use e-cigarettes following their smoking quit attempt, or take up e-cigarettes following smoking cessation. However, these potential SEP-trajectories have not yet been examined in detail. Disadvantaged smokers are thought to be more dependent on nicotine, due to taking up smoking generally at a younger age and smoking more cigarettes per day.[46] It is possible that such dependence[39] might encourage greater use of e-cigarettes following quitting in order to satisfy cravings and potentially prevent relapse to smoking. E-cigarettes may also be compatible with family responsibility and recreational use for pleasure rather than as a cessation device, aspects of disadvantaged smoker identity highlighted by recent ethnographic fieldwork in northern England.[167]

E-cigarettes have been on the UK market for approximately a decade, allowing for an examination of the trends in use among ex-smokers that are using the devices. Using data from the Smoking Toolkit Study (STS) (2014 to 2019), the aims of this current study were to assess trends in e-cigarette use according to SEP by examining:

1. Current use of e-cigarettes among all long-term ex-smokers (quit smoking for >1 year).

2. i) Recent and ii) late uptake of e-cigarettes following smoking cessation, respectively, among:

   a) Past-year ex-smokers who did not use an e-cigarette in their quit attempt (recent uptake).

   b) Long-term ex-smokers who quit smoking before e-cigarettes became popular in 2011 (late uptake).

To contextualise observed trends of e-cigarette use against another widely available non-combustible nicotine delivery product, this study will also assess trends in the use of nicotine replacement therapy (NRT) by SEP in the same categories of ex-smoker described in aims 1) and 2a) described above.

4.2 Methods

3.2.1 Design

This study followed a repeated cross-sectional survey design (see Chapter 3 for further details). Smoking Toolkit Study (STS) data collected from January 2014 to September 2019 were used. As in the previous study outlined in Chapter 3, 2014 was selected as the referent year because it was the first year in which the STS measured e-cigarette use among all respondents.

The Smoking Toolkit Study has been approved by University College London's Research Ethics Committee (ID: 0498/001) and participants provided fully informed consent. The data are anonymised when received by University College London. The STROBE guidelines were used in the design and reporting of this study.[247]

3.2.2 Measures

Main Outcomes

E-cigarette and NRT use among long-term (>1-year) ex-smokers

Responses to the question "Smoking status" were used to identify long-term ex- smokers. Those who selected the answer option "Stopped >1y ago" were classified as long-term ex-smokers.

Responses to the question "Can I check, are you using any of the following?" were used to identify the nicotine product being used. Respective answer selections of 'Electronic Cigarette' and NRT (response options include nicotine patch, nicotine gum, nicotine lozenges/Tablets, nicotine inhaler, nicotine nasal spray) in response to the question were used as the outcome measures for e-cigarette and NRT usage among respondents.

Prevalence of use of e-cigarettes and NRT (respectively) among long-term ex-smokers were calculated by counting the number of respondents who endorsed use of either product to the above question, divided by the number of long-term ex-smokers.

Recent uptake of e-cigarette or NRT among past-year ex-smokers who did not use these products in their quit attempt

Responses to the question "Smoking status" were used to identify ex-smokers. Those who selected the answer option "Stopped in past year" were classified as past-year ex-smokers.

Responses to the question "What did you use to help stop smoking during the most recent serious quit attempt?" were used to identify past-year ex-smokers who used either an e-cigarette or NRT, respectively, in their quit attempt. Answer selection of "Electronic cigarette" or any form of NRT (respectively) indicated respective product use and triggered exclusion of such participants from the subsequent analysis. The remaining sample therefore included ex-smokers who quit smoking within the past year without using e-cigarettes or NRT in their quit attempt. Current use of either product among this sample would indicate uptake following a quit attempt.

Current e-cigarette or NRT use were ascertained as described above in response to the question "Can I check, are you using any of the following?". Answer selections of 'Electronic Cigarette' and NRT (response options include nicotine patch, nicotine gum, nicotine lozenges/Tablets, nicotine inhaler, nicotine nasal spray) respectively in response to the question were used as the outcome measures for e-cigarette and NRT usage among respondents.

Prevalence of use of e-cigarettes and NRT (respectively) among past-year ex- smokers were calculated by counting the number of respondents who endorsed use of either product to the above question outside of a quit attempt, divided by the number of past-year ex-smokers who had reported quitting without assistance from the respective products.

Late uptake of e-cigarettes among long-term ex-smokers who quit smoking before the year 2011 (when e-cigarettes became popular)

As a measure of late uptake of e-cigarettes, we assessed current e-cigarette use among ex-smokers who had quit before e-cigarettes had become popular in 2011 (i.e. more than 8 years ago). Length of abstinence from smoking (how many years ago they quit smoking) was calculated from responses to the below questions:

Actual age? Age when stopped smoking?

Length of abstinence (years) = Actual age (years) – Age when stopped smoking (years)

To create sub-groups of ex-smoking respondents for each year from 2014 to 2019 who had quit smoking before 2011, the length of abstinence calculated above is used as follows:

2014: Respondents with length of abstinence ≥ 4 years

2015: Respondents with length of abstinence ≥ 5 years

2016: Respondents with length of abstinence ≥ 6 years

2017: Respondents with length of abstinence ≥ 7 years

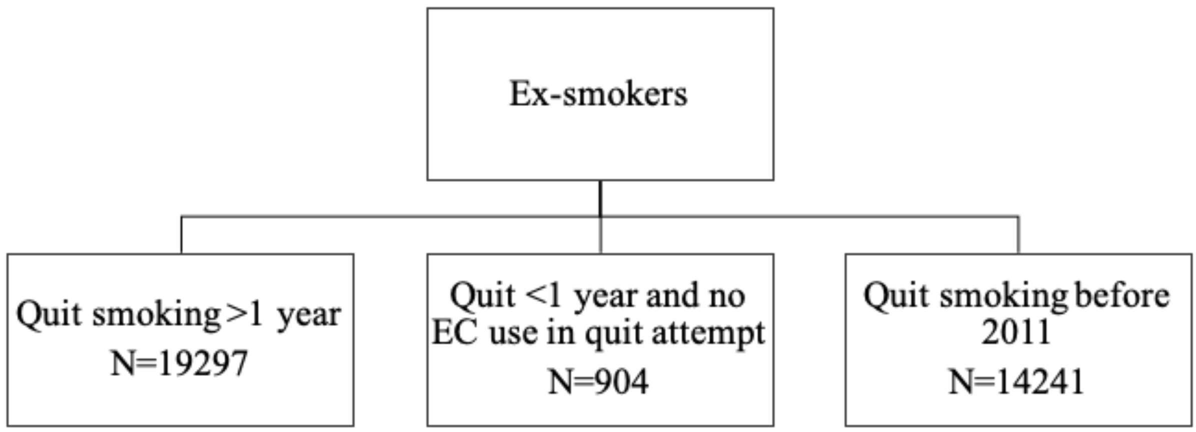
2018: Respondents with length of abstinence ≥ 8 years

2019: Respondents with length of abstinence ≥ 9 years

Current e-cigarette use was ascertained as described above in response to the question "Can I check, are you using any of the following?"

Answer selections of 'Electronic Cigarette' in response to the question were used as the outcome measures for e-cigarette usage among respondents. Prevalence of e-cigarettes use among pre-2011 ex-smokers were calculated by counting the number of respondents who endorsed use of e-cigarettes, divided by the number of pre-2011 ex-smokers. NRT use was not assessed here as they were widely available prior to 2011.

Figure 4.1: Sub-groups of ex-smokers selected for analysis



Explanatory variables

STS respondents were stratified according to SEP using the national readership survey (NRS) classification system for social grade based on occupation.[248] This measure typically contains five categories (AB, C1, C2, D and E), but was collapsed into two groups with higher and intermediate managerial, administrative and professional, supervisory, clerical and junior managerial occupations (termed ABC1) operationalised as a proxy for more advantaged SEP, and semi-skilled and unskilled manual workers, state pensioners, casual and lowest grade workers, unemployed with state benefits only (termed C2DE) operationalised as a proxy for disadvantaged SEP. Living in social housing is an independent risk factor for smoking in England [221]. Therefore, sensitivity analyses were conducted using housing tenure [227] as an alternative measure of SEP. This measure was collapsed into two groups, ‘social housing’ (local authority or housing association) and ‘Other’ (mortgage bought, owned outright, private renting and other).

Adjusting e-cigarette and NRT use by ex-smokers for background popularity of each respective product

Prevalence of e-cigarettes and NRT use by ex-smokers were adjusted for background popularity of each product, respectively, in the general population by including use in the general population as the denominator, thus expressing each subgroup's prevalence as a percentage of use in the general population.

$$\text{Prevalence of e-cigarette use} = \frac{\text{Total number of ex-smokers using e-cigarette}}{\text{Total number of e-cigarette users in general population}}$$

Covariates

Sociodemographic characteristics

The sociodemographic characteristics sex (categorised as women or other), age (categories 16-24, 25-34, 35-44, 45-54, 55-64, 65+) and region in England (London, North East, North West, Yorkshire and Humber, East Midlands, West Midlands, East of England, South East, South West) were also be measured.

3.2.3 Analysis

To assess trends in the associations between e-cigarette or NRT use (respectively) and year among ex-smokers, we constructed logistic regression models including survey year (categorical predictor variable with referent year 2014) and SEP (two categories with ABC1 as the referent) and the interaction terms.

All associations are reported stratified by year. Odds ratios (ORs) with 95% confidence intervals (adjusted for age, sex and region) indicate the associations between e-cigarette use and year or SEP. The inclusion of the SEP*year interaction terms allowed us to examine any differential time trends according to SEP (i.e. differences in the rapidity of change).

The analyses for e-cigarette and NRT use (respectively), were reported both overall and stratified by SEP:

i) Prevalence of use among all long-term ex-smokers

ii) Prevalence of use among past-year ex-smokers who did not use an e-cigarette in their quit attempt.

iii) Prevalence of use among long-term ex-smokers who quit smoking before 2011.

After examining cases, only n=40 (0.2%) long-term ex-smokers, n=3 past-year ex-smokers (0.3%) and n=6 (0.04%) pre-2011 long-term ex-smokers reported using both e-cigarettes and NRT. Because these numbers were low, and the primary objective of this study was to examine trends in e-cigarette use, with NRT prevalence over the same time period presented for context, these users were not excluded from the main analysis).

Sensitivity analyses were run using housing tenure as an alternative measure of SEP. Results on prevalence of use for i) - iii) above were also plotted with adjustment for background popularity in the general population.

Unregistered changes to analysis plan

Quasi-complete separation occurred in the yearly stratified models involving past-year ex-smokers. This is because uptake of e-cigarettes and NRT, respectively, among past-year smokers who did not use the product in their quit attempt is a rare outcome and not all response levels for certain demographic covariates (age and region) contained data.

To resolve this, the covariates were merged to become dichotomous predictors (age: 16-44 vs 45+; region: South vs North). In this same sub-group, there were no women who used an e-cigarette in 2019, so the sex variable was dropped from the 2019 model.

4.3 Results

A weighted total of 19,297 long-term (>1 year) ex-smokers (mean age=59.24, 46.77% women), 904 past-year ex-smokers who did not use an e-cigarette in their recent quit attempt (mean age=41.60, 49.26% women) and 1,353 past-year ex-smokers who did not use NRT in their recent quit attempt (mean age = 40.60, 46.59% women) in England completed the baseline STS survey between January 2014 and September 2019 (inclusive). The sub-group of ex-smokers (2014-2019) who had been quit before 2011 included 14,241 respondents (mean age=63.61, 46.48% women) (Table 4.1).

Table 4.1: Characteristics of sample (weighted data)

Variables	LT ex-smokers[a] (2014-2019) n (%)	Pre-2011 LT ex-smokers[b] (2014-2019) n (%)	<1-year ex-smokers[c] (2014-2019) n (%)	<1-year ex-smokers[d] (2014-2019) n (%)
Overall	19297 (100)	14241 (100)	904 (100)	1353 (100)
EC use				
Yes	1361 (7.05)	155 (1.09)	67 (7.41)	-
No	17936 (92.95)	14086 (98.91)	837 (92.59)	-
NRT use				
Yes	590 (3.06)	317 (2.23)	-	50 (3.69)
No	18707 (96.94)	13923 (97.77)	-	1303 (96.31)
Sex				
Women	9024 (46.77)	6619 (46.48)	445 (49.26)	631 (46.59)
Age (years)				
16-24	521 (2.70)	37 (0.26)	153 (16.87)	241 (17.84)
25-34	1814 (9.40)	596 (4.18)	241 (26.61)	340 (25.13)
35-44	2571 (14.26)	1707 (11.99)	193 (21.36)	300 (22.17)
45-54	3434 (17.80)	2463 (17.30)	143 (15.80)	228 (16.82)
55-64	3555 (18.42)	2885 (20.26)	92 (10.13)	139 (10.24)
65+	7222 (37.42)	6552 (46.01)	83 (9.23)	106 (7.81)
SEP				
ABC1	11408 (59.12)	8776 (61.63)	478 (52.89)	693 (51.22)
C2DE	7889 (40.88)	5464 (38.37)	426 (47.11)	660 (48.78)

Ns are weighted. EC = Electronic cigarette; NRT = Nicotine Replacement Therapy; SEP = Socio-economic position; ABC1 = higher SEP (higher and intermediate managerial, administrative and professional, supervisory occupations, clerical and junior managerial occupations); C2DE = lower SEP (semi-skilled and unskilled manual workers, state pensioners, casual and lowest grade workers, unemployed with state benefits only); [a]All long-term ex-smokers (quit smoking >1-year); [b]Long-term ex-smokers who quit smoking before 2011; [c]<1-year ex-smokers that did not use e-cigarettes in their most recent quit attempt; [d]<1-year ex-smokers who did not use NRT in their most recent quit attempt;

E-cigarette use among long-term ex-smokers

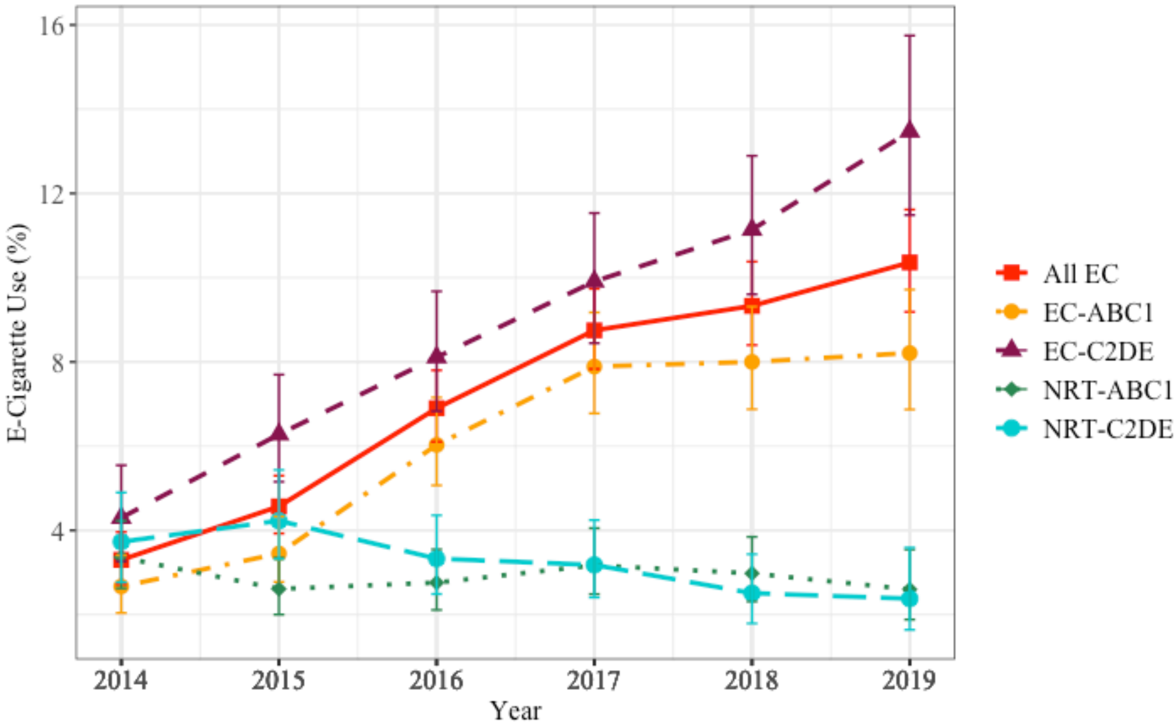
Weighted e-cigarette and NRT prevalence statistics for long-term ex-smokers, stratified by SEP (e-cigarette use is also plotted overall), are shown for each year from 2014 to 2019 in Figure 4.2.

A trend in e-cigarette use across time was evident among long-term ex-smokers, whereby all respondents, regardless of SEP (there were no significant interactions between SEP and time), were more likely to use e-cigarettes in each year from 2016 to 2019 compared with 2014 (Table 4.2). Overall, lower SEP respondents were more likely to use e-cigarettes compared with more advantaged respondents. When stratified by year this socio-economic gradient in e-cigarette use remained with the exception of the year 2016 when there was no clear evidence of an association with SEP (Table 4.3).

There was no clear trend in NRT use across time, or evidence of an association between SEP and NRT use in each year, with the exception of 2015 where long-term ex-smokers from group C2DE were more likely to use NRT compared with those in group ABC1 (Tables 4.4 and 4.5).

E-cigarette and use among long-term ex-smokers as a percentage of use in the general population increased from 10.53% (95% CI 8.76-12.60) in 2014 to 30.48% (27.43-33.72) in 2019. This trend was also evident across SEP groups, increasing from 11.30% (8.73-14.52) to 31.88% (27.32-36.81) in ABC1 and 9.84% (7.59-12.69) to 29.36% (25.35-33.71) in C2DE (Appendix 6 Figure A6.1).

Figure 4.2: Trends in e-cigarette and NRT use among long-term ex-smokers 2014-2019



Ns are weighted

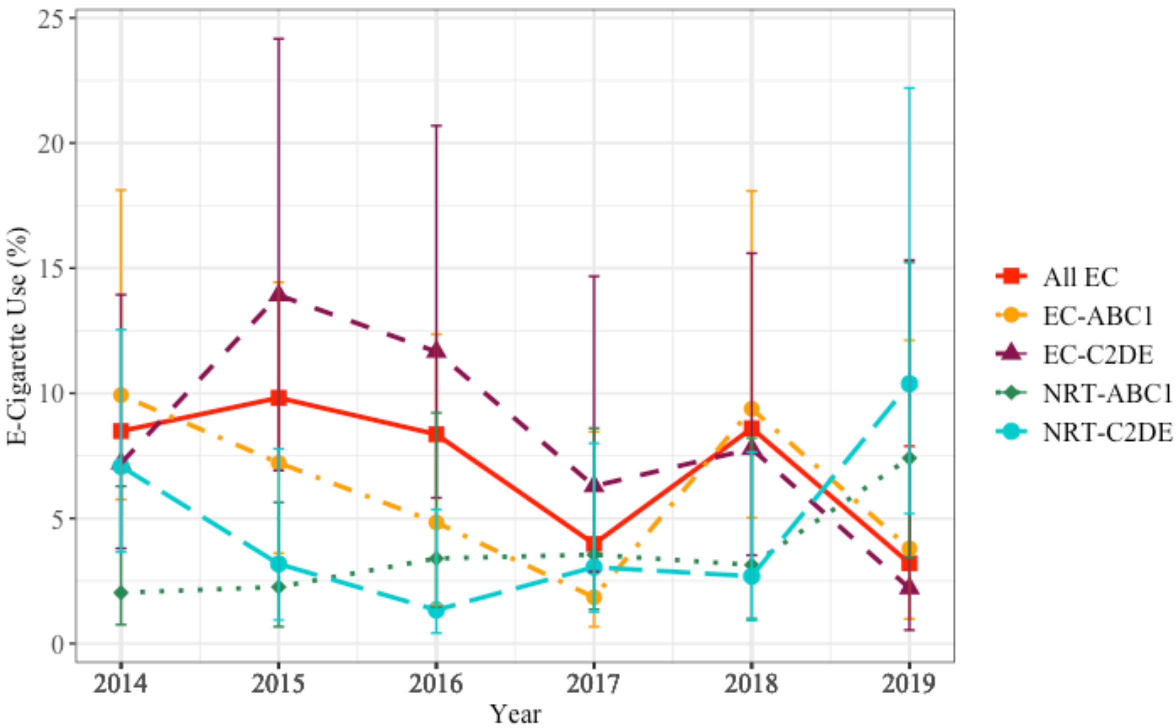
Recent uptake of e-cigarettes following cessation among past-year ex-smokers

Weighted e-cigarette and NRT prevalence statistics for past-year ex-smokers who did not use an e-cigarette or NRT in their most recent quit attempt (respectively) stratified by SEP (e-cigarette use is also plotted overall), are shown for each year from 2014 to 2019 in Figure 4.3.

With the exception of the year 2017, where e-cigarette use was less likely compared with 2014, there was no clear trend over time for e-cigarette use (Table 4.2) or NRT use (Table 4.4) in this sub-group. With the exception of the year 2015 where use was more likely among lower SEP respondents, there were no apparent differences according to SEP in each year (Table 4.3). There was little interaction between SEP and time. The exception was that use in C2DE depended on year, with higher comparative prevalence in 2017 compared with 2014, relative to group ABC1.

Overall, e-cigarette use as a percentage of use in the general population decreased from 1.72% (1.07-2.74) in 2014 to 0.37% (0.12-1.07) in 2019 (Appendix 6, Figure A6.2). In group ABC1 use decreased from 2.17% (1.19-3.95) in 2014 to 0.54% (0.15-1.96) in 2019. In group C2DE use decreased from 1.5% (0.77-2.96) in 2014 to 0.22% (0.04-1.24) in 2019.

Figure 4.3: Recent uptake of e-cigarettes and NRT 2014-2019



Ns are weighted. E-cigarette and NRT use among past-year ex-smokers who did not use either product, respectively, in their most recent quit attempt.

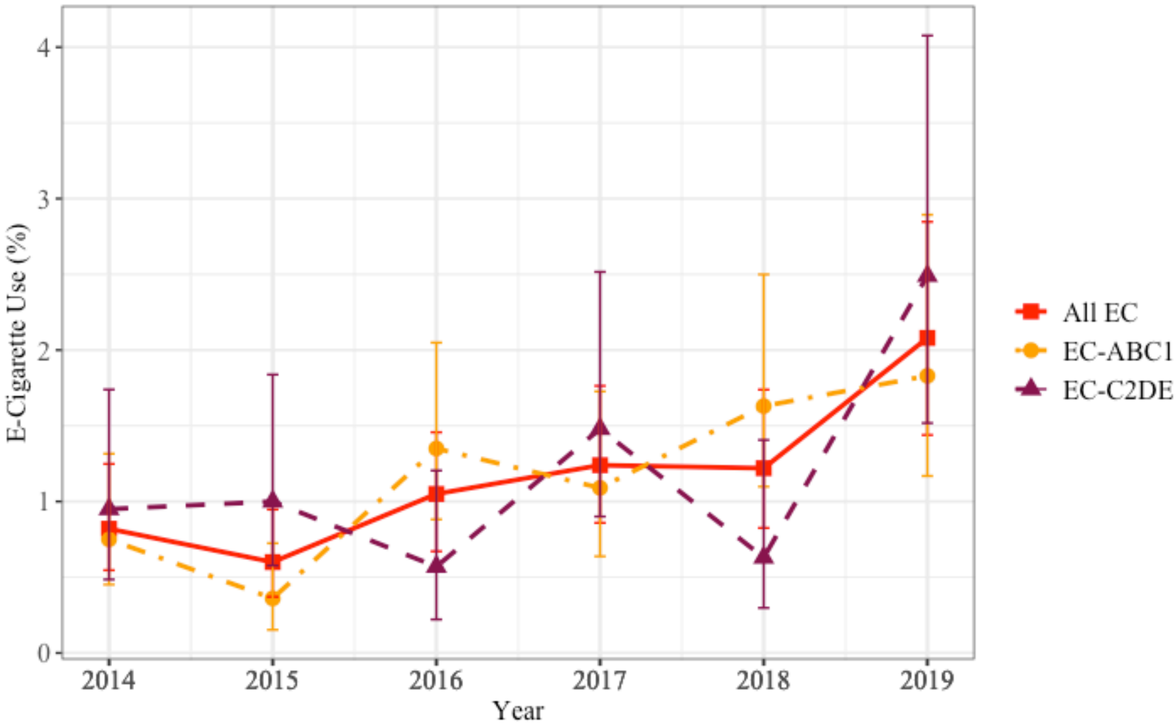
Late uptake of e-cigarettes among long-term ex-smokers who quit before 2011

Weighted e-cigarette prevalence statistics for ex-smokers who quit smoking before the year 2011, stratified by SEP (use is also plotted overall), are shown for each year from 2014 to 2019 in Figure 4.4.

A trend in e-cigarette use across time was evident, whereby all respondents, regardless of SEP, were more likely to use e-cigarettes in 2018 and 2019 compared with 2014 (Figure 4.4 and Table 4.2). There were no interactions between SEP and time. With the exception of the year 2015 where use was more likely among lower SEP respondents, there were no apparent differences according to SEP in each year (Table 4.3).

Overall e-cigarette use among pre-2011 long-term ex-smokers as a percentage of use in the general population was estimated to have increased from 2.23% (1.47-3.35) in 2014 to 4.02% (2.88-5.60) in 2019 (Appendix 6 Figure A6.3). In the advantaged group use increased from 2.82% (1.66-4.77) in 2014 to 4.90% (3.12-7.62) in 2019. In the lower SEP group use increased from 1.70% (0.90-3.21) in 2014 to 3.31% (2.02-5.39) in 2019.

Figure 4.4: Late uptake of e-cigarettes 2014-2019



Ns are weighted. E-cigarette use among pre-2011 ex-smokers (quit smoking before the year 2011).

Table 4.2: Associations between e-cigarette use and year of survey and SEP among i) long-term ex-smokers, ii) past-year ex-smokers and iii) pre-2011 long-term ex-smokers in England (2014-2019).

	Long-term ex-smokers[a] (N=19842)	***P***	**<1-year ex-smokers**[b] (N=870)	***P***	**Pre-2011 LT ex-smokers**[c] (N=15063)	***P***
SEP						
ABC1	1 [Reference]		1.00 [Reference]		1.00 [Reference]	
C2DE	1.59 (1.05–2.40)	.03	0.54 (0.18-1.55)	.26	1.25 (0.47-3.21)	.62
Year						
2014 ref	1 [Reference]		1 [Reference]		1 [Reference]	
2015	1.29 (0.88-1.90)	.20	0.54 (0.16-1.67)	.31	0.43 (0.13-1.22)	.13
2016	2.34 (1.66-3.37)	<.001	0.42 (0.09-1.52)	.21	1.93 (0.92-4.32)	.09
2017	2.88 (2.06-4.09)	<.001	0.18 (0.03-0.73)	.03	1.50 (0.68-3.47)	.32
2018	3.19 (2.29-4.54)	<.001	0.70 (0.22-2.10)	.54	2.79 (1.37-6.13)	.006
2019	3.46 (2.45-4.97)	<.001	0.31 (0.05-1.28)	.22	3.29 (1.56-7.40)	.005
Interaction terms						
2015*C2DE	1.23 (0.73-2.10)	.44	4.63 (0.95-24.13)	.07	2.39 (0.56-10.9)	.25
2016*C2DE	0.79 (0.48-1.31)	.36	4.53 (0.81-29.90)	.09	0.47 (0.12-1.72)	.26
2017*C2DE	0.85 (0.52-1.37)	.50	7.21 (1.06-65.99)	.05	1.35 (0.41-4.57)	.63
2018*C2DE	0.87 (0.54-1.40)	.57	1.39 (0.24-7.63)	.72	0.39 (0.11-1.37)	.15
2019*C2DE	0.97 (0.59-1.60)	.67	1.70 (0.07 - 23.82)	.95	0.99 (0.30-3.31)	.98

Ns are not weighted. All models are adjusted for age, sex and region. Results are presented as Odds Ratios (95% CI) against the indicated referent. [a]Long-term (>1-year) ex-smokers; [b]Past year ex-smokers who did not use an e-cigarette in their most recent quit attempt; [c]Long-term ex-smokers who quit smoking before 2011 (late uptake). SEP = Socio-economic position; ABC1 = higher SEP (higher and intermediate managerial, administrative and professional, supervisory occupations, clerical and junior managerial occupations); C2DE = lower SEP (semi-skilled and unskilled manual workers, state pensioners, casual and lowest grade workers, unemployed with state benefits only)

Table 4.3: Associations between e-cigarette use and SEP stratified by year among i) long-term ex-smokers, ii) past-year ex-smokers and iii) pre-2011 long-term ex-smokers in England (2014-2019).

	Year											
	2014	***P***	**2015**	***P***	**2016**	***P***	**2017**	***P***	**2018**	***P***	**2019**	***P***
LT ex-smokers[a]	(N=3170)		(N=3462)		(N=3533)		(N=3617)		(N=3532)		(N=2528)	
SEP												
ABC1 (N=12008)	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
C2DE (N=7834)	1.64 (1.08-2.5)	.02	2.01 (1.43-2.82)	<.001	1.27 (0.95-1.7)	.10	1.33 (1.03-1.73)	.03	1.35 (1.05-1.74)	.02	1.59 (1.19-2.11)	.001
PY ex-smokers[b]	(N=194)		(N=158)		(N=129)		(N=152)		(N=152)		(N=85)	
SEP												
ABC1 (N=479)	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
C2DE (N=391)	0.61 (0.21-1.73)	.35	3.46 (1.05-12.64)	.04	2.24 (0.56-11.18)	.27	3.12 (0.61-23.06)	.20	0.80 (0.19-3.07)	.75	0.97 (0.04-11.07)	.63
Pre-2011 LT ex-smokers[c]	(N=2683)		(N=2805)		(N=2703)		(N=2649)		(N=2501)		(N=1722)	
SEP												
ABC1 (N=9394)	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
C2DE (N=5669	1.12 (0.42-2.87)	.81	3.22 (1.06-10.81)	.04	0.51 (0.18- 1.21)	.15	1.74 (0.81-3.74)	.15	0.45 (0.18-1.00)	.06	1.20 (0.56-2.47)	.52

Ns are not weighted. All models are adjusted for age, sex and region. Results for prevalence of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. [a]Long-term (>1-year) ex-smokers; [b]Past year ex-smokers who did not use an e-cigarette in their most recent quit attempt; [c]Long-term ex-smokers who quit smoking before 2011 (late uptake). SEP = Socio-economic position; ABC1 = higher SEP (higher and intermediate managerial, administrative and professional, supervisory occupations, clerical and junior managerial occupations); C2DE = lower SEP (semi-skilled and unskilled manual workers, state pensioners, casual and lowest grade workers, unemployed with state benefits only)

Table 4.4: Associations between NRT use and year of survey and SEP among i) long-term ex-smokers and past-year ex-smokers (2014-2019).

	LT ex-smokers[a] (N=19842)	***P***	**PY e-smokers[b]** (N=870)	***P***
SEP				
ABC1	1 [reference]		1 [reference]	
C2DE	1.20 (0.81–1.79)	.36	2.87 (0.81-13.46)	.13
Year				
2014 ref	1 [reference]		1 [reference]	
2015	0.77 (0.52-1.14)	.19	0.54 (0.07-3.38)	.48
2016	0.90 (0.62-1.30)	.55	1.22 (0.22-6.90)	.86
2017	0.98 (0.69-1.41)	.92	1.22 (1.26-6.43)	.83
2018	0.91 (0.63-1.31)	.60	1.45 (0.31-7.63)	.66
2019	0.87 (0.58-1.29)	.43	2.52 (0.63-12.43)	.19
Interaction terms				
2015*C2DE	1.39 (0.80-2.43)	.25	0.94 (0.10-9.70)	.97
2016*C2DE	0.97 (0.55-1.70)	.92	0.09 (0.01-1.10)	.09
2017*C2DE	0.89 (0.51-1.55)	.68	0.30 (0.03-2.21)	.26
2018*C2DE	0.76 (0.43-1.36)	.36	0.20 (0.02-1.63)	.15
2019*C2DE	0.73 (0.37-1.40)	.46	1.50 (0.06-3.18)	.49

Ns are not weighted. All models are adjusted for age, sex and region. Results for prevalence of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. $p<0.005$ p values are indicated in bold. *$p<0.01$, **$p<0.001$. [a]Long-term (>1-year) ex-smokers; [b]Past year ex-smokers who did not use an NRT in their most recent quit attempt; SEP = Socio-economic position; ABC1 = higher SEP (higher and intermediate managerial, administrative and professional, supervisory occupations, clerical and junior managerial occupations); C2DE = lower SEP (semi-skilled and unskilled manual workers, state pensioners, casual and lowest grade workers, unemployed with state benefits only)

Table 4.5: Associations between NRT use and SEP stratified by year among i) long-term ex-smokers and ii) past-year ex-smokers in England (2014-2019).

	Year											
	2014	***P***	**2015**	***P***	**2016**	***P***	**2017**	***P***	**2018**	***P***	**2019**	***P***
Long term ex-smokers[a]	(N=3170)		(N=3462)		(N=3533)		(N=3617)		(N=3532)		(N=2528)	
SEP												
ABC1 (N=12008)	1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]	
C2DE (N=7834)	1.12 0.74-1.66)	.59	1.66 (1.11-2.48)	.02	1.22 (0.81-1.84)	.33	1.05 (0.71-1.55)	.80	0.89 (0.57-1.36)	.59	0.85 (0.49-1.45)	.60
PY-ex-smokers[b]	(N=194)		(N=158)		(N=129)		(N=152)		(N=152)		(N=85)	
SEP												
ABC1 (N=479)	1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]	
C2DE(N=391)	3.04 (0.85-14.34)	.11	3.16 (0.58-23.74)	.20	0.27 (0.01-2.23)	.27	1.10 (0.21-5.29)	.90	0.45 (0.06-2.50)	.38	1.26 (0.30-4.79)	.61

Ns are not weighted. All models are adjusted for age, sex and region. Results for prevalence of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. p<0.005 p values are indicated in bold. *p<0.01, **p<0.001.
[a]Long-term (>1-year) ex-smokers. [b]Past year ex-smokers who did not use an e-cigarette in their most recent quit attempt.
SEP = Socio-economic position; ABC1 = higher SEP (higher and intermediate managerial, administrative and professional, supervisory occupations, clerical and junior managerial occupations); C2DE = lower SEP (semi-skilled and unskilled manual workers, state pensioners, casual and lowest grade workers, unemployed with state benefits only)

Sensitivity analyses

Using housing tenure as an alternative measure of SEP yielded a similar pattern of results to the main analysis (Appendix 6, Tables A6.1 and A6.2). Among long-term ex-smokers, those of social housing tenure had greater odds of using an e-cigarette overall and in each year compared with those of more advantaged tenure. There were no clear interactions with year. The exception was that prevalence in social housing compared with other (owned outright and private renting) among long-term ex-smokers depended on year, with the positive relationship between social housing and e-cigarette use weaker in the year 2017. Among past-year ex-smokers who did not use an e-cigarette in their most recent quit attempt, there was no clear housing tenure patterning or interaction with year. Finally, among pre-2011 ex-smokers, respondents were more likely to use e-cigarettes in 2018 and 2019 compared with 2014 irrespective of housing tenure. There was no interaction between housing tenure and time.

4.3 Discussion

From 2014 to 2019 in England, among long-term ex-smokers, e-cigarette use increased over time and was highest among respondents of more disadvantaged SEP. Among past-year ex-smokers who did not use an e-cigarette during their most recent quit attempt, there were no clear trends over time, or socio-economic differences, in e-cigarette use. Use by ex-smokers who had quit smoking before 2011 was greater in year 2018 and 2019 compared with 2014, but there was no clear evidence of a difference according to socio-economic position throughout the time period.

The findings on e-cigarette use among long-term ex-smokers reveal a continuation of the trends observed in the previous chapter from in England[253], with overall increased use over time and greater use among more socio-economically disadvantaged respondents compared with more advantaged respondents. This is concordant with recently published data from the UK Household Longitudinal Study, where socio-economic disadvantage was associated with e-cigarette use among ex-smoking adults.[255] However, this recent study only assessed whether respondents self-reported as either current, ex, or never smokers and could not explore e-cigarette use in specific sub-categories of ex-smokers as we have attempted to do in this current study.

Findings from the US population (previously highlighted in Chapter 3), where e-cigarettes are similarly popular, appear to show a divergent trend whereby e-cigarette use is more likely among socio-economically advantaged ex-smokers.[169,170] This heterogeneity in e-cigarette use by SEP between different countries around the world has been highlighted by a recent systematic review, where analysis of studies from 11 countries found mixed patterns of e-cigarette current use by SEP.[256] Such differences may be a reflection of different health policy and advocacy environments towards e-cigarettes in England compared with other countries where the devices have become popular. However, these comparisons are once again made with caution because the trajectories in use may change as shown in Chapter 3, comparisons should be at equivalent time points in their popularity.

In this current study long-term ex-smokers were also found to make up an increasing percentage of e-cigarette users in the general population over time. These results likely reflect the continued use of e-cigarettes following smoking cessation. Comparing e-cigarette use by SEP highlighted that although there have been consistent increases over time among lower SEP long-term ex-smokers, this is not apparent among more advantaged respondents where use appears to have stabilised. Such socio-economic patterning in e-cigarette use is important considering studies showing vaping ex-smokers reporting greater confidence in staying quit compared with non-vaping ex-smokers.[133,257] This is contextualised by the absence of a trend in the use of NRT, another widely available nicotine product, across the time period. However, a recent randomised controlled trial that showed e-cigarettes to be almost twice as effective for smoking cessation at 1 year compared with NRT[138] has indicated that, in the context of the trial, the devices may not confer extra protection against relapse. The trial found that time to relapse and relapse rates among participants with sustained abstinence at 4 weeks were very similar between the two trial arms despite large differences in ongoing use (80% of those in the e-cigarette arm were using their allocated product at 52 weeks compared with 9% in the NRT arm). NRT is likely more widely used as a medium-term quitting-aid, unlike e-cigarettes, which appear more popular for longer duration. Therefore, compared with NRT the added value of e-cigarettes may not be due to a greater protection against relapse, but rather due to greater efficacy for smoking cessation.[258]

The current absence of evidence on relapse protection along with increasing levels of prolonged use among ex-smokers of greater socio-economic disadvantage make this area an urgent research priority. If e-cigarettes do not confer the public health benefit of protection against relapse to smoking, then equity-positive advantages of long-term usage are less evident because although safer than smoking, use of the devices is not without risk.

The use of e-cigarettes among past-year ex-smokers who did not use an e-cigarette in their most recent quit attempt did not appear to change over time or differ by SEP.

Therefore, any potentially positive or negative outcomes from the use of e-cigarettes at the population-level will likely affect people equally across the socio-economic spectrum, making it unlikely that use in this specific sub-group will have a substantial impact on smoking related health inequalities.

Despite not falling on a social gradient, the use of e-cigarettes among pre-2011 ex-smokers who quit smoking before 2011 increased over time overall and was significantly higher towards the end of the time period compared with 2014. This sub-group also made up an increasing percentage of e-cigarette users in the general population. Although the change appears modest, it suggests that in addition to continued use as a quitting aid, increases in e-cigarette use may in part be due to late uptake among long-term ex-smokers. These pre-2011 long-term ex-smokers represent those who quit smoking before e-cigarettes arrived on the UK market. These older (mean age=63.60) sub-group of ex-smokers may have taken up e-cigarettes to prevent relapse to tobacco smoking, or because of the attractive nicotine delivery properties and lower harm profile of the devices. Given that these long-term ex-smokers had maintained abstinence from smoking without any assistance from e-cigarettes, it is plausible that they would have been able to remain abstinent in their absence. Our findings suggest that the uptake of e-cigarettes in this group is unlikely to impact on health inequalities, but further research is needed to understand the reasons behind the observed increase in use overall. Two recent prospective research studies in the US has suggested that use of e-cigarettes by former smokers may increase the likelihood of a return to tobacco smoking.[259,260] The first study by McMillen et al[259] examined former smokers who had quit smoking for ≥5 years before the baseline survey, but could not control for measures of nicotine dependence or lifetime tobacco use, which may be important psychosocial confounders of relapse. The second study by Everard et al[260] examined the trajectories of former smokers who were not using e-cigarettes or tobacco products at baseline, and found that the use of e-cigarettes was strongly associated with relapse to smoking. This finding is most relevant for the two subgroups in this current study who initiated e-cigarette use only after they had quit smoking. However, if the devices were increasing the likelihood of a return to smoking in England then one would expect the prevalence of e-cigarette use among long-term ex-smokers to stabilise or decline as many of them return to smoking. This is unlikely based on evidence from this study. Furthermore, one would also expect to see a slowing down in the rate of reduction of smoking following the advent of e-cigarettes. As yet this does not appear to be the case, with consistent reductions in smoking year on year.[131] Interestingly, the sample of distant ex-smoker respondents in the aforementioned US McMillen study who reported relapsing to past 30-day combustible tobacco smoking were more likely to be younger (18-34 vs 35+). This may represent a phenomenon unique to the US context, where although strongly associated with lifetime tobacco use and perhaps a reflection of common liability to addiction, youth e-cigarette use has sharply increased in recent years.[155,261,262] This is in contrast to the UK where weekly e-cigarette use among former smoking youth (age 11-18) is estimated to be 3.3% and almost negligible among never smokers.[263]

Strengths of this study include its large representative sample of the population in England, allowing an in-depth and generalizable interrogation of e-cigarette use over time in specific ex-smoking sub-groups. Furthermore, the use of a different measure of SEP in a sensitivity analysis provided convergent results with the main analysis. However, the results are limited by the use of self-reported cross-sectional survey data, where smoking status was not biochemically verified. It is also challenging to measure e-cigarette consumption levels accurately without a validated quantifiable measure.

4.4 Conclusion

In conclusion, this study found that from 2014 to 2019 in England, e-cigarette use increased over time among all long-term ex-smokers and was most likely in those of lower SEP. Use among past-year smokers who did not use an e-cigarette in their most recent quit attempt was similar over time and by SEP. Among all ex-smokers who quit smoking before 2011, e-cigarette use increased since 2014 but there were no differences according to SEP. This socio-economically patterned use of e-cigarettes among long-term ex-smokers is therefore unlikely due to recent or late uptake of e-cigarettes post-cessation, and most probably reflects continued use of e-cigarettes as a long-term cessation aid in those of more disadvantaged SEP.

The population-level modelling of e-cigarette use discussed in this chapter and the previous chapter have highlighted important socio-economic distributions and trends in England. However, these quantitative analyses do not allow for a deeper exploration of the reasons why there appear to be differences in e-cigarette use by SEP. To help explain these observed trends, an interrogation of usage patterns and perceptions of e-cigarettes among socio-economically disadvantaged individuals in the contexts of quitting smoking is necessary. A mixed methods exploration, that goes some way towards this goal, is the subject of the remaining chapters in this thesis.

Chapter 5

Patterns of 'smart' e-cigarette use among socio-economically disadvantaged smokers: an exploratory mixed methods study (Study 4)

Abstract

The phenomenon of greater e-cigarette use among lower SEP long-term ex-smokers at the population-level in England may be influenced by patterns and attitudes towards the devices during a smoking quit attempt. This mixed methods feasibility study aimed to i) explore objectively recorded smart e-cigarette usage data and compare it with a self-reported ecological momentary assessment (EMA) of quantity and frequency of device usage in a lower SEP sample and ii) explore the attitudes and opinions that socio-economically disadvantaged smokers have towards e-cigarette use in a quit attempt. Lower SEP smokers were provided with a Gram or JUUL C1 smart e-cigarette for two weeks to support a smoking quit attempt. At two-week follow-up, participants attended a one-to-one semi-structured interview and underwent biochemical verification if they self-reported seven consecutive days without smoking; N = 9 adult smokers (22% female, median age = 52) were recruited between September 2019 and March 2020. Passively recorded device usage data revealed that six participants had less frequent and stable patterns of usage over the study period compared with three participants who had generally higher frequency and more erratic patterns of usage. Two participants were

biochemically verified as abstinent at follow-up. Five participants had at least 1 cigarette-free day and 2 participants did not have any cigarette-free days.

Where data were available, comparisons between self-reported EMA data on e-cigarette usage with objectively recorded e-cigarette usage found there to be poor correspondence for both the number of sessions with the device in a day (Cohen's kappa (k)=0.07), and the number of puffs taken in the most recent session (k=0.19) All participants planned to continue use of an e-cigarette to support their current or future quit attempt. The reasons cited for quitting smoking with an e-cigarette were related to improving health and saving money, and due to a feeling of responsibility to quit for their family. E-cigarettes were thought to be an effective smoking cessation tool, and were for some an enjoyable activity, despite scepticism about how well e-cigarettes suppressed urges to smoke cigarettes. Several participants described that poor mental health had disrupted their ability to quit smoking during their current and previous quit attempts.

Overall, participant interviews and patterns of usage at the early stage of a smoking quit attempt highlight the potential of e-cigarettes to support more heavily dependent lower SEP smokers in a quit attempt.

5.1 Background

Smoking cessation interventions have the potential to exacerbate health inequalities arising from smoking due to socio-economic differences in delivery, access and effectiveness.[114] The preceding chapters have highlighted that there are reasons to be optimistic about the impact of e-cigarettes in England. Regulated devices are widely available as a consumer product, and appear to be similarly effective[250] and popular for smoking cessation across the social spectrum[131] and use by long-term ex-smokers is more prevalent among those from lower compared with higher SEP.[253] The reasons for the emerging social gradient in e-cigarette use among ex-smokers outlined in Chapter 4 is poorly understood and may result from different attitudes towards ECs and their use during a quit attempt, which warrants further investigation. This chapter used mixed methods to explore usage and the attitudes and opinions that socio-economically disadvantaged smokers have towards e-cigarette use in a quit attempt.

Views and attitudes towards e-cigarettes

Several previous qualitative studies have explored factors that influence the use of e-cigarettes for smoking cessation. Factors described by this research include smokers understanding of the relative harms compared with cigarettes, greater flexibility as to where the devices can be used, and perceived effectiveness for smoking cession.[264–266] A review of e-cigarettes for smoking cessation among vulnerable groups (those with mental illness, recovering form substance abuse, homeless or those detained in the criminal justice system) suggested that the devise had potential to replace certain aspects of cigarette addiction, including the perceived pleasure and habit of smoking.[267] Ethnographic research conducted with socio-economically disadvantaged communities in northern England has suggested that e-cigarette use was acceptable due to compatibility with aspects of feelings of family responsibility to quit smoking, and also because for younger users the devices conferred an enjoyable experience irrespective of their utility for smoking cessation.[167,268]

Understanding potential treatments and tools to promote smoking cessation requires an understanding of motivation beyond a broad analysis of the costs and benefits of enacting the behaviour of quitting smoking. PRIME theory[11] (section 1.1) is a synthetic theory of addiction that along with the evaluative beliefs about the benefits and drawbacks of smoking also encapsulates other important aspects of cigarette addiction, including the habits and urges that smokers experience.[173] E-cigarette use is a distinct behaviour to smoking, but has certain comparable characteristics (nicotine delivery, inhalation of vapour, hand to mouth action) that lend themselves to investigation under the conceptual framework of PRIME theory.

Measuring e-cigarette usage

New digital technologies are able to provide access to information on health behaviour that were previously only available through self-report by the individual, such as cigarette smoking or e-cigarette use.[269] Although acknowledged to be safer than cigarette smoking, the long-term effects of e-cigarette use are less clear, and differences in usage have potential to impact on future health inequalities. It is therefore important to develop reliable measures of usage patterns to allow for assessment of epidemiological associations between e-cigarette use and health outcomes.

To my knowledge, there is limited research comparing self-reported measures of EC usage with objective measures of consumption. A 'smart' e-cigarette allows researchers to examine e-cigarette usage with greater accuracy in real-time,[270] which is important given that usage patterns likely have an impact on how effective the devices are in supporting a smoking quit attempt.[271] A smart e-cigarette called 'Gram' has been developed by Gram research (www.gramresearch.com), a US vaping technology company that manufactures e-cigarette devices to track usage. Gram works with a smartphone application (app) to sample, record, and log time-stamped digital "pulses" (with a sampling rate 50 ms) that measure real-time changes in the device's voltage, providing an objective measure of usage. Other large manufacturers of e-cigarettes, such as JUUL have also developed app-enabled devices that can be used to monitor usage in real-time, but their use in any ongoing research studies has not yet been published.

Use of the Gram devices in previous research highlighted several usage patterns during a smoking quit attempt.[270] These included i) immediate and intensive e-cigarette use coupled with immediate and sustained reductions in cigarette consumption, ii) gradual e-cigarette initiation along with gradual smoking reductions and iii) e-cigarette experimentation with little change in smoking. Participant interviews conducted at the time of a quit attempt with a smart e-cigarette such as the Gram may help explain these apparently distinct patterns of usage. The objectively recorded device usage that is permitted through use of the Gram and other smart e-cigarettes also provides an opportunity to compare and evaluate the accuracy of self-reported survey measures on e-cigarette use. Self-reported device use can be measured using ecological momentary assessments (EMA). In the form of surveys delivered via a smart-phone app or text message, EMAs can involve repeated sampling of a participant's current behaviour and experiences in real-time.[272] This sampling can help reduce recall bias associated with a participant trying to remember a frequent and intermittent behaviour at a later moment[273], and EMAs have been shown to be useful for tracking smoking.[269]

In the context of an attempt to stop smoking, this feasibility study aimed to i) explore objectively recorded e-cigarette usage and compare it with self-reported measures of quantity and frequency of device usage in a lower SEP sample and ii) explore the attitudes and opinions that more socio-economically disadvantaged smokers have towards e-cigarette use in a quit attempt.

5.2 Methods

5.2.1 Study design

5.2.1.1 Sample and recruitment

I aimed to recruit a purposive sample of 15-20 eligible adult smokers who wanted to make a quit attempt, were willing to use an e-cigarette to do so, and who either owned an android smartphone or were willing to use a UCL study-provided android smart phone. Recruitment was to be conducted with a stopping criterion once interviews appeared to have reached data saturation (the point at which no novel themes or codes emerge from the qualitative data). Unfortunately, having recruited only nine participants the study was stopped early due to the social distancing measures mandated by the UK government in response to the COVID-19 epidemic. This meant that I was not able to recruit the 15 participants initially specified for this study, and conduct a full assessment of data saturation. However, to gain some indication of progress towards data saturation, I completed a data saturation assessment wherein themes and interviews were tabulated, with a row for each theme and with each column representing each participant interview. New themes continued to emerge after analysing the first nine interviews (Appendix 7 Table A7.1), which suggested that data saturation had not been reached with the interview sample.

Participants of lower SEP were recruited through advertisements (Appendix 7 Figure A7.1) in three local newspapers in London. With consent, advertisements for the study were also placed at GP clinics, on community billboards, and on flyers placed in cafes and local vape shops. The advertisements included a contact number for participants to call for a brief screening survey with me to determine eligibility. Participants were excluded if they had regularly (≥weekly) used an EC as part of a quit attempt in the 3 months before study entry, were pregnant or breastfeeding, or were less than 18 years old. Ethical approval for the study was granted by the UCL research ethics committee (8323/004).

5.2.1.2 Procedure

Participants were required to enrol in the study for two weeks (Figure 5.4). The two-week time period was chosen because i) the Gram device is relatively burdensome (it must always be accompanied by an android phone and an associated app in order to activate) and ii) during a quit attempt most untreated smokers relapse to smoking during the first week following a quit attempt.[55]

After being screened via a telephone survey, eligible participants visited UCL for their baseline session. Then, after providing written consent to participate in the study each participant received advice about how to use their Gram device and the associated phone application, and an information booklet outlining the study procedures. At baseline participants completed a short questionnaire on socio-demographic and smoking characteristics and were asked to confirm their smoking status via an exhaled Carbon Monoxide (CO) monitor.

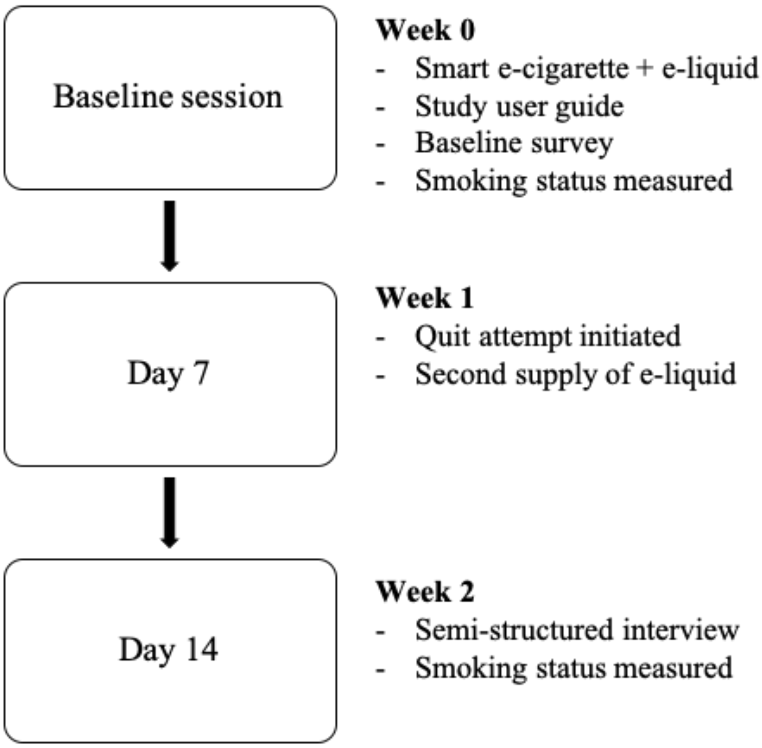
Participants were then provided with a Gram and a week supply of e-liquid (flavour options tobacco, menthol, fruit; concentration options 18mg/ml, 12mg/ml, 6mg/ml), and were asked to familiarise themselves with the device for the first week and prepare to use it as part of their quit attempt. The Gram EMA app was set up to deliver a set of questions to participants immediately after a vaping session (pushed to a participant's smartphone after 10 minutes of Gram device inactivity), asking them questions related to the frequency of puffs in the most recent session. All e-cigarette sessions and EMA surveys were timestamped, allowing self-reported EMA and objectively measured device usage to be matched and compared (see section 5.3). A 'daily diary' EMA survey was also delivered to participants at the end of each day with questions asking them to self-report the number of sessions with the Gram they had that day. The definition of what constituted an e-cigarette session is outlined in section 5.3 below. Due to Gram functionality problems some participants were provided with a JUUL C1 device (see section 5.2.2.2) and a one-week supply of e-liquid (nicotine concentration of 9mg/ml). After one week, participants returned to UCL to pick up a further one-week supply of e-liquid and to provide any informal feedback about participation. They were then asked to begin their quit attempt.

At the end of week two participants returned to UCL for their follow-up session. Abstinence from smoking was defined as at least seven consecutive smoke-free days. Participants were considered as smoking if they had at least 5 cigarettes since the start of their quit attempt. Those who self-reported abstinence were biochemically validated blowing into a CO monitor.

Participants consented to a one-to-one semi-structured interview. I conducted these interviews myself and they aimed to provide some context to the quantitative data collected in this study, these interviews explored participant experiences of using an e-cigarette in a quit attempt using a simple framework (see section 5.3).

At the end of the study period all participants were provided with a free second-generation e-cigarette device and referred to their local stop smoking service to continue their quit attempt. These devices were provided given the ethical concerns related to taking away an e-cigarette from participants when it may have been successfully supporting their quit attempt. Following the interview, and on condition of the safe return of the Gram or JUUL C1 each participant was given a £20 online shopping voucher.

Figure 5.1: Summary of procedure



For personal reasons, one participant (P6) was only able to participate in the study for one week, with follow-up and interview conducted on day seven.

5.2.1.3 Disruption due to the COVID-19 epidemic in England

In advance of the likely shutdown of activities and social distancing measures mandated by the UK government in response to the COVID-19 epidemic, recruitment for this study was ceased on March 13th, 2020. This limited the completion of data collection and resulted in a smaller sample being recruited than originally intended.

5.2.2 Devices

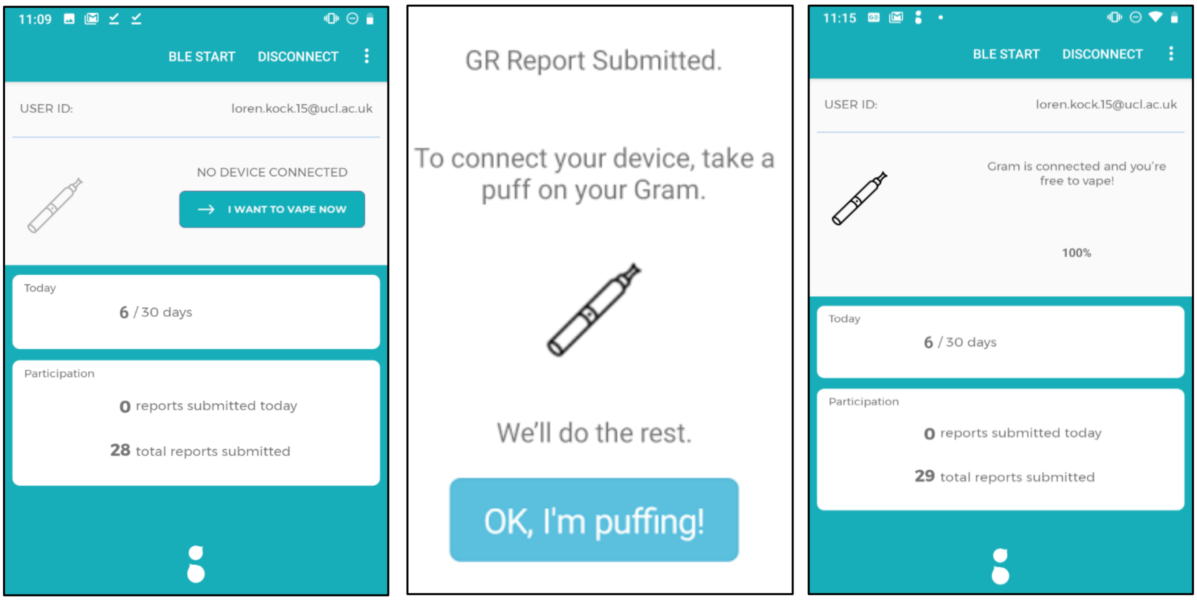
5.2.2.1 The Gram smart e-cigarette

The device used, known as 'Gram', is a Bluetooth enabled vape-pen style e-cigarette (Figure 5.2) developed by Gram research (www.gramresearch.com) in California. The Gram was paired with an android smartphone app (also developed by Gram Research) to sample, record, and log time-stamped digital "pulses" (with a sampling rate of 50 ms) that measured real-time changes in the device's voltage. These discrete changes indicated that the device was being used and tracked the number of puffs in a vaping 'session', the timed duration of the session, and the number of sessions each day.

Figure 5.2: Gram smart e-cigarette

Pulse data was stored on participants' android smartphones and automatically uploaded to a cloud-based database whenever the phones were connected to the internet. Each device had a unique anonymous identifier (ID) associated with all relevant pulses that allows linkage between individual pulses and specific participants IDs. To use the Gram, participants were required to pair their device via Bluetooth with a UCL study ID on the associated Gram app on an android smartphone (Figure 5.3). This procedure allowed all usage data to be immediately captured on the app in real-time before being anonymously uploaded to the UCL study site situated on the Gram server.

Figure 5.3: Screenshots of device pairing procedure on Gram android application.



The Gram app also delivered EMA multiple choice survey questions (Figure 5.2 and measures section 5.2.3.1) to participants immediately following a session of Gram usage or at specified times, such as at the end of each day, allowing them to self-report how often they had puffed on their device in the most recent session, and the number of vaping sessions with the device they had in a given day.

5.2.2.2 JUUL C1

Participants reported functionality problems with the Gram device to the point they became unusable. Issues with the Gram device are discussed in the limitations section. Due to these functional problems, the Gram devices were replaced with JUUL C1 devices for the final three participants (P7, P8 and P9). Designed and manufactured by JUUL labs, the JUUL C1 'connected device' is a Bluetooth enabled cartridge-based e-cigarette that, through pairing to an Android smartphone application, allowed users to monitor device usage, including puffs and sessions (Figure 5.4). Anonymous UCL study accounts were set up on the JUUL app on a UCL study android smartphone for each respective participant.

Figure 5.4: JUUL C1 starter kit and associated Android application

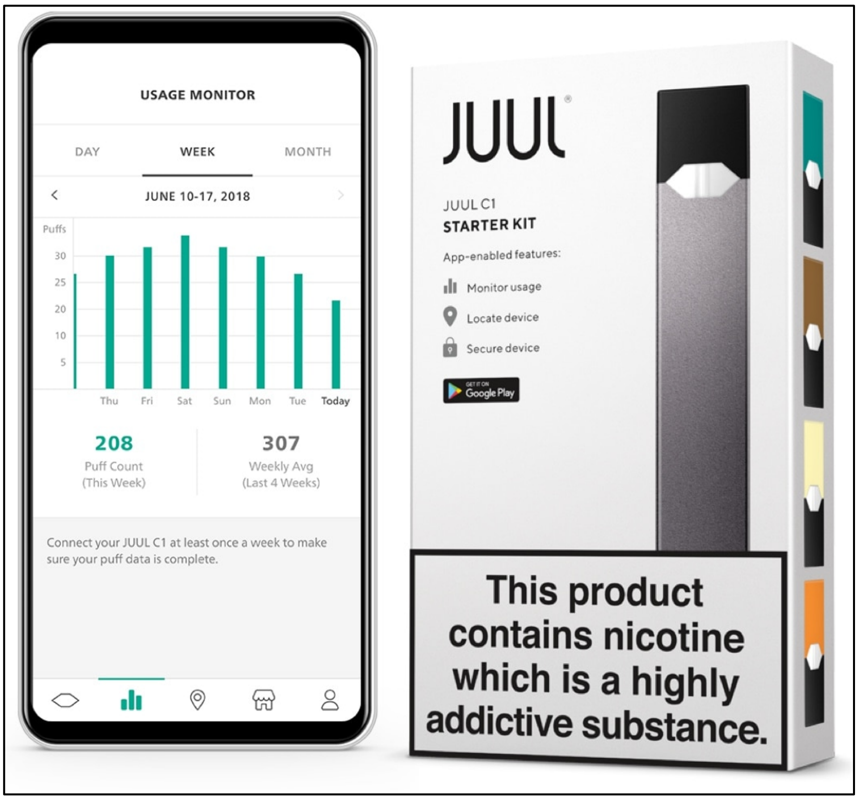


Image source: www.JUUL.co.uk

The three JUUL C1 participants were only enrolled in the study for one week with a quit date on day one and follow-up and interview on day seven due to practical limitations related to my travel to attend an international conference, which was immediately followed upon my return by restrictions related to the COVID-19 epidemic in the UK.

5.2.3 Measures

The following variables were measured at baseline:

- Age
- Sex
- SEP (operationalised using social grade based on occupation)
- Number of cigarettes per day
- Number of years smoked

Participant SEP was operationalised using the National Readership Survey (NRS) classification of social grade based on occupation.[248]

5.2.3.1 Gram EMA

The core items listed below were adapted from e-cigarette usage questionnaires such as the Penn State E-Cigarette Dependence Index (PSECDI)[274], the e-cigarette Fagerström Test of Cigarette Dependence (e-FTCD) and the e-cigarette Wisconsin Inventory of Smoking Dependence Motives (e-WISDM).[275] These self-report items relate directly to Gram usage and are comparable with the passive data on consumption collected via the device itself.

The questions were included in core EMA surveys immediately following e-cigarette usage, or in a 'dairy diary' at the end of each day (Figure 5.3). The daily diary was pushed to participants in the evening when they were expected to be at home and had more time to complete the short survey. Several other supplementary items (Appendix 7) related to e-cigarette dependence were programmed into the Gram EMA surveys, but the response rates to these questions were too low (see section 5.3) to allow any meaningful presentation in this study and they are therefore not included in the analysis. An e-cigarette session was described to participants as a consistent period of puffing, where each puff or group of puffs occurred within ten minutes of the previous. Therefore, when a puff was taken at least ten minutes after the previous puff, they should consider this an initiation of a new session.

Immediately following a Gram session

How many puffs on the e-cigarette did you take in your most recent session?

a) 0
b) 1-5
c) 6-10
d) 11-14
e) 15+

Daily diary

Did you use your e-cigarette today?

a) Yes
b) No

How many times did you use your e-cigarette today?

a) 0
b) 1-5

c) 6-10

d) 11-15

e) 16-20

f) 21+

Did you smoke any cigarettes today?

a) Yes

b) No

How many cigarettes did you smoke today?

a) 0

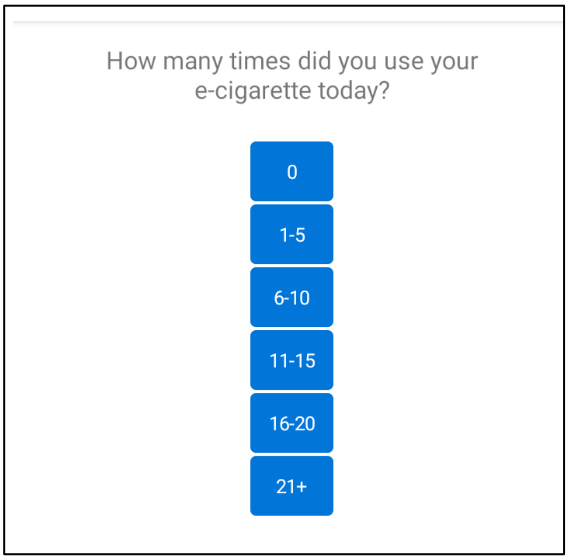
b) 1-5

c) 6-9

d) 10-14

e) 15+

Figure 5.5: Screenshot of an example 'daily diary' EMA delivered via the Gram app



Unlike participants using Gram devices, a post-session EMA was not possible for the three participants provided with a JUUL C1. These three participants were instead asked to complete the same daily diary survey questions described above, but by email or text message.

5.3 Analysis

5.3.1 Descriptive statistics on device usage

Descriptive statistics on device usage were calculated for each participant for both the number of daily sessions, and the number of puffs in the most recent session with the Gram or JUUL C1 device. Due to the small sample size and missing data these data are presented descriptively without any further analysis so as to provide some context for the qualitative data presented in section 5.4.5. Participants are grouped according to self-reported number of cigarette free days (biochemically verified as not smoking for seven consecutive days, some cigarette-free days, no cigarette-free days).

5.3.2 Inter-measure reliability

Number of daily sessions with device

The self-reported EMA data was compared with the objectively measured Gram or JUUL C1 data to indicate the proportion of self-reported responses that correctly recalled the actual number of sessions had taken place each day. This coverage is displayed visually in simple point chart, allowing for a calculation of the percentage of the total number of correct self-reported EMA responses.

Number of puffs on device in most recent session

By comparing the self-reported EMA data with the objectively measured Gram data, it was possible to count how many of the self-reported responses correctly recalled the actual number of puffs that had taken place in each session. This coverage is also displayed visually in a simple point chart, allowing for a calculation of the percentage of the total number of correct self-reported EMA responses.

Cohen's kappa

The reliability of the self-reported EMA data for i) the number of daily sessions and ii) the number of puffs in the most recent session was estimated using Cohen's kappa. Cohen's kappa (*k*) is a dimensionless index that can be used to estimate the agreement between two raters or categorical measures (in this case the self-reported EMA and objective Gram puff measurements) in a single number. Where data were available, I used the kappa statistic to quantity inter-measure agreement on the nominal scales of sessions per day and puffs reported in the most recent session for each participant. Poor agreement (generally values of *k* between 0 and 0.20) would suggest that the self-report EMA was not a reliable measure of e-cigarette puff recall (Table 5.2) for that individual.[276,277]

Table 5.1: Values of k and guidance on the strength of agreement between measures

Value of *k*	Strength of agreement
<0.20	Poor
0.21-0.30	Fair
0.41-0.60	Moderate
0.61-0.80	Good
0.81-1.00	Very good

5.3.3 Attitudes towards e-cigarette use in a quit attempt

At the end of week two (the end of a participant's study period), each participant was invited to attend a one-to-one interview with me. To provide some context for the quantitative data collected in this study, and using the conceptual framework of PRIME theory (section 1.1), the interviews explored aspects related to smokers' motivation to use an e-cigarette in a quit attempt (see Appendix 7 for topic guide). There was a focus on plans to continue to use an e-cigarette or make a quit attempt with an e-cigarette in future, evaluative beliefs about e-cigarette and conventional cigarette use, and motivations and impulses related to e-cigarettes and quitting smoking (Table 5.2).

The interview topic guide was also informed by recent research conducted among low-SEP communities in northern England.[268] This research suggested that e-cigarette use is compatible with aspects of working-class characteristics such as family responsibility and sociable hedonism whereby the devices are regarded as a rewarding activity regardless of any benefits towards smoking cessation.

Table 5.2: Summary of PRIME theory of motivation in relation to a quit attempt with an e-cigarette.

PRIME construct	Definition
Plans	Self-conscious intentions to continue to use e-cigarette (if abstinent) or to use e-cigarette again in future quit attempt.
Impulses	Urges to smoke or use e-cigarette.
Motives	Wants (anticipated pleasure or satisfaction) and needs (anticipated relief from discomfort) of e-cigarette use.
Evaluations	Beliefs about e-cigarette use, smoking and quitting smoking with an e-cigarette.
Internal stimuli	Drives (nicotine hunger) and emotional states (pleasure and discomfort) related to e-cigarette use or smoking.
External stimuli	Other people using e-cigarettes. Available information on e-cigarettes. External influences encouraging or discouraging use.

Unfortunately, due to the early cessation of this study described in section 5.2, interviews were stopped after only nine participants and before data saturation was reached for a several emerging themes (Appendix 7 Table A7.1). However, established themes are presented in the results section under the respective domain of PRIME theory that I considered them to fall under.

5.4 Results

A total of nine individuals were recruited into the study. Seven (78%) of the sample were male, the median age of the sample was 52 years (range 24-72). Seven (78%) of the sample were not currently employed. The sample had smoked for a mean of 49.8 years (standard deviation (SD) = 13.4) and seven participants estimated that they smoked on average more than ten cigarettes per day (Table 5.3).

Table 5.3: Participant characteristics

Participant ID	Age	Sex	Social grade	Years smoked	*Cigarettes per day	Device
1	57	Male	E (Unemployed)	40	>10	Gram
2	39	Male	E (Unemployed)	20	>10	Gram
3	45	Male	E (Unemployed)	37	>10	Gram
4	52	Male	E (Unemployed)	38	>10	Gram
5	24	Male	E (Unemployed)	9	<10	Gram
6	47	Female	E (Unemployed)	32	>10	Gram
7	72	Male	E (Retired)	56	<10	JUUL
8	55	Female	D (Casual work)	20	>10	JUUL
9	57	Male	E (Unemployed)	30	>10	JUUL

*Baseline cigarettes per day; Social grade D = Semi-skilled and unskilled manual workers; Social grade E = State pensioners, casual and lowest grade workers, unemployed with state benefits only.

5.4.1 Missing data

Given that there was no specific requirement for e-cigarette usage (participants were permitted to use their Gram or JUUL C1 as often or as little as they wished), there were some days on which several participants (P2, P3, P4 and P5) did not use the Gram device (Table 5.4). P8 temporarily misplaced the JUUL device after four days, before finding it again on day seven. As such, no data is shown for days five to seven.

Furthermore, there were variable response rates to core daily diary EMA and post-session EMA surveys. The overall response rate to the daily EMA e-cigarette usage questions was 26.4% (23 completed out of a total of 87 that were pushed to participants). Five participants (P2, P3, P5, P8 and P9) did not respond to any daily diary EMA surveys. Of the four participants (P1, P4, P6 and P7) that provided some daily diary responses, only two of them (P6 and P7) responded to all daily surveys, and their responses were restricted to the questions on e-cigarette device usage and whether they had smoked any cigarettes that day (i.e. no responses on how many cigarettes smoked per day were provided). P1 only responded to seven out of 12 (58.3%) possible daily diary EMA surveys, and P2 only responded to 5 out of 12 (41.6%) possible daily diary EMA surveys. Where not missing, daily diary device usage data is presented for these participants, and pooled for an overall comparison between the self-reported EMA measure and objective measure of usage.

Four Gram users (out of a possible six) completed post-session EMA surveys. However, these surveys were not completed for every session. For n = 454 sessions overall across all four participants, only n = 76 (16.7%) had matched post-session EMA responses. Therefore, comparisons between the self-reported EMA and objectively measured Gram session data are only shown for sessions where there were timestamped and matched data for both measures of usage.

Finally, no participants completed any of the supplementary EMA questions that were included in the EMA applicable to the assessment of e-cigarette dependence (See Appendix 7 for survey items).

5.4.2 Descriptive summary of device recorded usage

5.4.2.1 Sessions per day

Device data on passively recorded sessions per day during the study is shown for each participant in Table 5.4. There was within and between participant variation in device usage. Relatively stable usage (a regular pattern of sessions per day) was apparent for n

= 6 participants who had a range of daily sessions less than or equal to five (Table 5.4). The number of sessions per day fluctuated substantially for three participants (P1, P4 and P9). These three individuals also had the most sessions on their device over the study period, and in qualitative interviews self-reported symptoms of poorer mental health (section 5.4.5). Five participants self-reported to have maintained abstinence some days, but ultimately relapsed to smoking before the end of the study. Those verified as not smoking at follow-up (n = 2) had the lowest average number of sessions on their device per day in the whole sample and did not use their device on six days, respectively. These two individuals (P2 and P5) were the youngest members of the sample, and had been smoking for the fewest years. There were no observable differences in measures between the two device types.

5.4.2.2 Puffs per session

Device data on passively recorded puffs per session during the study is shown for each participant in Table 5.5. As with the analysis of sessions per day, there was considerable within and between participant variation in the number of puffs per session. All participants displayed fluctuating counts of puffs per session, which is evident from the unstable estimates for mean and median puffs for each individual in Table 5.5. No data on puffs per session could be pulled for participants provided with a JUUL C1 device (n = 3) because there was no way to download the data from the application, and it is not clearly discernible from visual observation of the user statistics presented within it.

Table 5.4: Gram and JUUL C1 sessions and smoking measures

ID	Device	Nicotine strength (mg/ml)	Total sessions	Days with device	Number days device used	Mean (SD) sessions/day	Median (range) sessions/day	Number of cigarette free days	Smoking status (CO reading)
Biochemically verified as not smoking at follow-up									
2	Gram	18	15	14	8	1.1(1.3)	1 (0-4)	7	Abstinent (1-5)
5	Gram	18	22	14	8	1.6 (1.9)	1 (0-5)	7	Abstinent (1-5)
Self-reported some cigarette free days									
6*	Gram	12	16	7	7	2.3 (1.4)	2 (1-5)	5	Smoking
8*	JUUL	9	50	7	4	12.5 (1.3)	12.5 (11-14)	3	Smoking
9*	JUUL	9	73	7	7	10.4 (6.5)	9 (3-21)	3	Smoking
1	Gram	18	181	12	12	15.1 (8.5)	12.5 (6-32)	3	Smoking
3	Gram	18	11	7	4	1.6 (1.7)	1 (0-4)	1	Smoking
Self-reported no cigarette-free days									
4	Gram	18	60	12	10	5.0 (4.4)	4.5 (0-14)	0	Smoking
7*	JUUL	9	26	7	7	3.7 (0.5)	4 (3-4)	0	Smoking

*P3 device failed after seven days. P7, P8 and P9 study follow-up shortened to seven d

Table 5.5: Gram and JUUL C1 puffs per session and smoking measures

ID	Device	Nicotine strength	Total sessions	Days with device	Mean (SD) puffs/session	Median (range) puffs/session	Number of cigarette free days	Smoking status (CO reading)
Biochemically verified as not smoking at follow-up								
2	Gram	18	15	14	19.0 (16.8)	15 (1-64)	7	Abstinent (1-5)
5	Gram	18	22	14	9.5 (7.7)	6.5 (1-26)	7	Abstinent (1-5)
Self-reported some cigarette free days								
6*	Gram	12	16	7	8.6 (6.3)	8 (2-22)	5	Smoking
8*	JUUL	9	50	7	NA	NA	3	Smoking
9*	JUUL	9	73	7	NA	NA	3	Smoking
1	Gram	18	181	12	32.3 (19.3)	29 (4-97)	3	Smoking
3	Gram	18	11	7	29.5 (29.6)	26 (3-93)	1	Smoking
Self-reported no cigarette-free days								
4	Gram	18	60	12	22.4 (19.8)	11 (1-65)	0	Smoking
7*	JUUL	9	26	7	NA	NA	0	Smoking

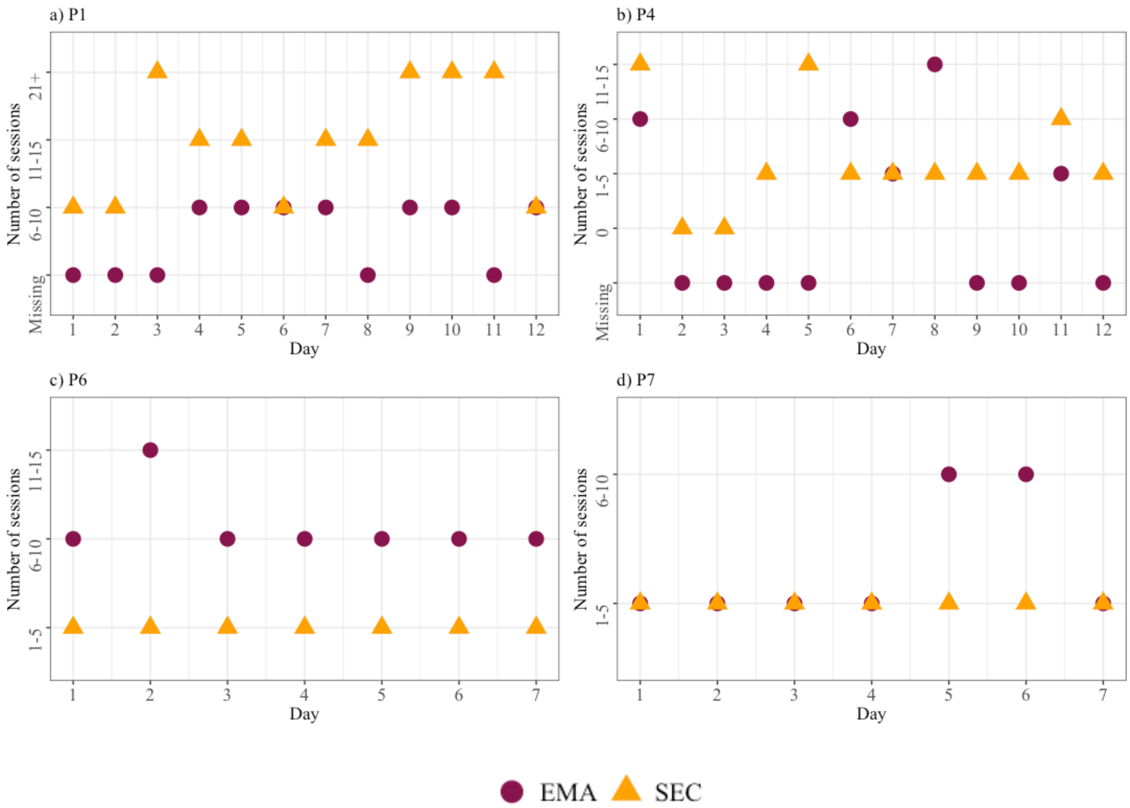
*P3 device failed after 7 days. P7, P8 and P9 study follow-up shortened to seven days; NA = Data on puffs per session were not available for participants using a JUUL C1 device

5.4.3 Reliability of self-reported EMA measures

5.4.3.1 EMA sessions per day vs objectively recorded device data

Daily diary EMA data was only available for participants P1, P4, P6 and P7 (Figure 5.5). P1 and P4 did not respond to the EMA on a total five and seven days out of a possible 12, respectively. The percentage of responses from each participant that correctly covered the objective device data ranged from 20% (P4) to 71.4% (P7). Available EMA data was pooled for an estimate of reliability of the daily diary self-report EMA as a measure of daily device sessions. Eight (30.8%) of the EMA responses correctly covered the objective e-cigarette usage data. Eleven responses over-estimated the number of sessions, and seven responses under-estimated the number of sessions had. Cohen's *k* was calculated to be 0.07 (Appendix 7), indicating poor agreement between the two measures (Tables 5.6a and 5.6b).[277]

Figure 5.6: Self-reported EMA sessions vs device recorded sessions (binned)*



*P7 data is from JUUL C1; Days where EMA responses were not provided are indicated as 'Missing'

Table 5.6a: Relative frequencies of daily diary EMA and device recorded responses

		EMA					
		1-5	**6-10**	**11-15**	**16-20**	**21+**	**TOTAL**
Gram	**1 -5**	0.23	0.35	0.08	0	0	0.65
	6-10	0.04	0.08	0	0	0	0.12
	11-15	0	0.15	0	0	0	0.15
	16-20	0	0	0	0	0	0.00
	21+	0	0.08	0	0	0	0.08
	TOTAL	0.27	0.58	0.08	0	0	1

Table 5.6b: Cohen's k for daily diary EMA vs device recorded responses

Proportion observed agreement	0.31
Proportion expected agreement	0.25
Observed - expected	0.05
k	0.07

5.4.3.2 Puffs per session EMA vs objectively recorded Gram data

Recent session EMA data was only available for participants P1, P4 and P6 (Figure 5.6). The percentage of responses from each participant that correctly covered the binned Gram usage data ranged from 32.6% (P1) to 53.8% (P6). Matched EMA and Gram puff data from these three participants (Figure 5.6) was pooled for an estimate of reliability for the self-reported EMA as a measure of puffs in the most recent device session. Twenty-eight (36.8%) of the EMA responses correctly covered the objective Gram device usage data. Eight responses over-estimated the number of sessions had, and 40 responses under-estimated the number of sessions had. Cohen's kappa (*k*) was calculated to be 0.19 (Appendix 7), indicating poor agreement between the two measures (Tables 5.7a and 5.7b).[276]

Figure 5.7 (a-c): Self-reported EMA puffs vs Gram device recorded puffs (binned)

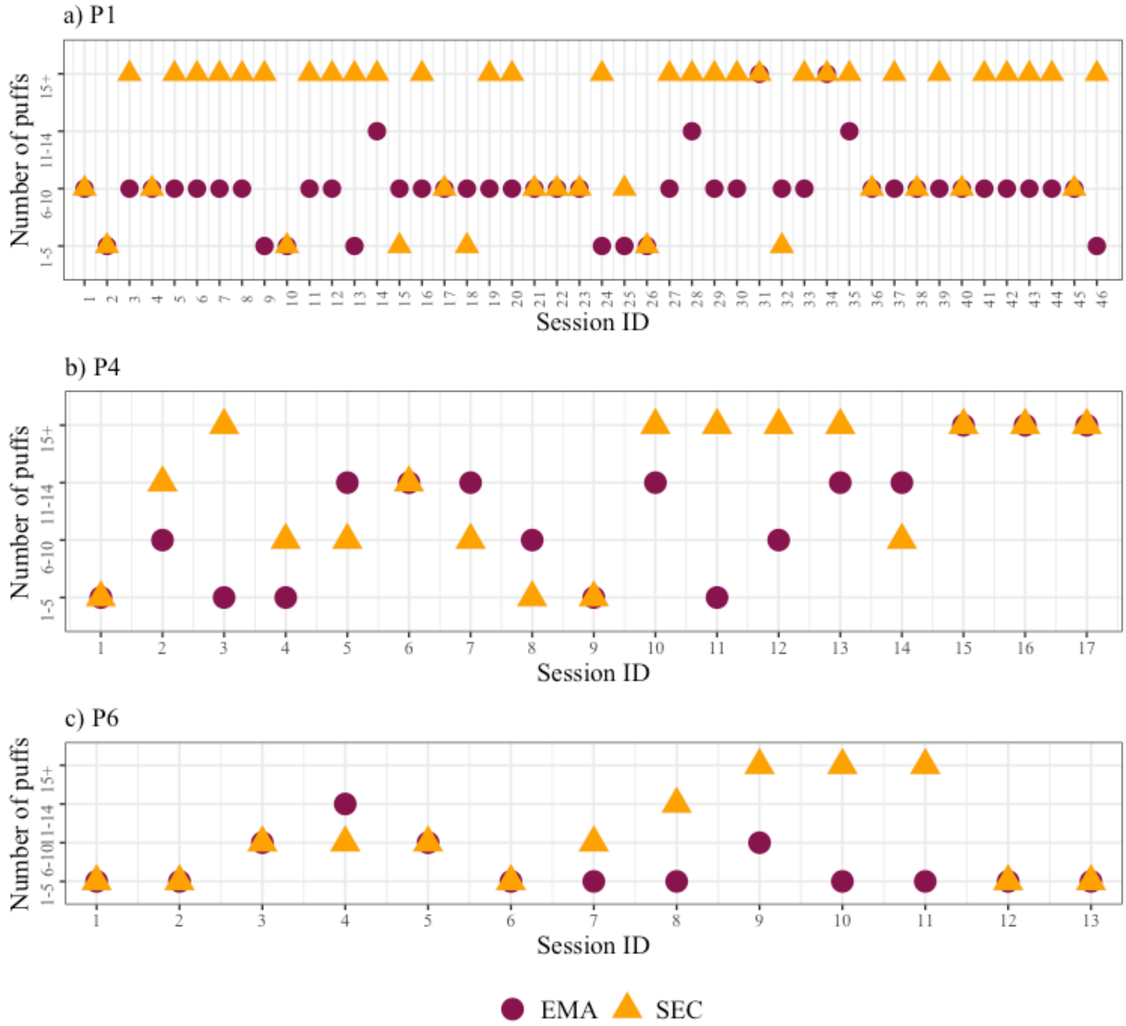


Table 5.7a: Relative frequencies of puffs per session EMA vs Gram device data

		EMA				
		1-5	**6-10**	**11-14**	**15+**	**TOTAL**
Gram	**1 -5**	0.14	0.05	0	0	0.19
	6-10	0.04	0.16	0.05	0	0.26
	11-14	0.01	0.01	0.01	0	0.04
	15+	0.11	0.30	0.04	0.07	0.51
	TOTAL	0.30	0.53	0.11	0.07	1

Table 5.7b: Cohens' k for puffs per session EMA vs Gram device

Proportion observed agreement	0.38
Proportion expected agreement	0.23
Observed - expected	0.15
K	0.19

5.4.4 Views and attitudes

Despite not achieving data saturation, several themes were emerging from the interview data. I have included these initial themes accompanied by participant quotes. A more detailed coding matrix is available in Appendix 7. There were no clear differences in the responses of participants using the Gram vs JUUL C1.

Plans

Theme 1: Persisting with the e-cigarette

All participants, including the two individuals who had successfully quit and all others that were still smoking at the end of the study-period planned to continue to use an e-cigarette to quit smoking. Finding a method and device that worked for them was an important factor.

"Yes, if it's an effective device. I found I had to go back on to tobacco from Saturday, but I slightly lost the taste for it, so I only need the odd one. Whereas before, with the other e-cigarettes I've tried, I'd use it then think, I really need a cigarette. From Saturday, I wish the e-cigarette was working because I would like to have had that instead of the cigarette." [P1]

P3 intended to use the e-cigarette, referring to the relative safety compared with smoking as a reason.

"Because I think it's better than smoking actual cigarettes. It's said that tobacco smoke contains over 70 substances known to cause cancer. Then there's other public health

warnings also attached to smoking. So, I do believe that the vape is far more beneficial." [P3]

Two participants were motivated to use the device in their current quit attempt but were mentioned wanting to stop using an e-cigarette at some point in future.

"I'm going to give it a good go. Because I meant to give up smoking, I want to give up smoking. I don't want to be smoking anything really. I've been very successful using the patches in the past, so, I don't know, we'll see." [P6]

<u>Evaluations</u>

Theme 2: Switching for health and finances

Most participants highlighted that they wanted to quit smoking to improve their health and noticed immediate improvements in their breathing and appearance during the week in which they attempted to switch to an e-cigarette.

"You feel stronger after you take the e-cigarette, not cigarette. Cigarette makes you weaker. This one makes you quite normal. It keeps your normal oxygen level." [P2]

"I'm a good swimmer and I haven't been good for the last couple of years, but I haven't been going. Since last week I've been back to the swimming. I found it hard for the first ten feet or for the first ten metres to swim with the smoking, and the next day without smoking it's different, you feel different. Whoever smoked, that's who will believe it, will see the difference." [P9]

"It's just the health is the most important thing, my health. I'm not young anymore, I'm not a spring chicken, we're growing old. It does affect your health big time, and the switch to vape is a good idea." [P9]

Financial concerns were regularly quoted in tandem with health reasons when participants were asked about why they wanted to stop smoking, and were using an e-cigarette to do so.

"It's not smoking as such, but you know in the back of your mind that this is nowhere near as harmful. I'm saving money." [P5]

"Financial and for my health. I can see within a week of stopping smoking, my skin looks clearer and things like that. Yes, for my health, absolutely. The smell doesn't linger and all those things, ashtrays." [P6]

"To save money, and for my health reasons, to save myself from any harm. And another one, to save money a little bit. I can save and I can do something else. Financial reason." [P2]

P1 stated that he was trying to quit smoking solely for financial reasons. He stated that he was not quitting because of his health, or family.

"From the point of view of having a cigarette and then thinking, I didn't really need it. Not so much from the fact that's another nail in the coffin. It's just that's a waste of time

and money almost. Certainly not from health reasons. I'm no spring chicken. No family. We've all got to go at some stage."

Motives

Theme 3: A tool and/or a pleasure

Mixed opinions were given on whether an e-cigarette offers more than just being a tool to help you quit smoking. Several saw e-cigarettes as both a useful tool and a pleasurable activity. P1 perceived himself to be a nicotine addict and that in this context derived pleasure from smoking or using an e-cigarette. He believed that e-cigarettes were a useful tool quit smoking because of this.

"I think the two are interlinked really. It's certainly to cut down and possibly to cut out the cigarettes altogether. You use these cigarettes or devices for enjoyment. If you didn't use them, you wouldn't be enjoying things quite as much. Not so much not enjoying things but you'd find life more difficult, definitely if you've been addicted to nicotine, and you can't stop through other means. I think I'll always be addicted to nicotine." [P1]

The e-cigarette was thought to provide some satisfaction on certain occasions when he would typically smoke a cigarette.

"I've had brief attempts with NRT and they didn't work. I like the feeling of inhaling and things like coffee after a meal. I really enjoyed having a cigarette with those and with a good e-cigarette, that'll satisfy those cravings as well." [P1]

P2 thought vaping was a pleasurable activity in and of itself, regardless of any utility to quit smoking.

"It's not just about stopping smoking. It's for pleasure as well, excitement, and a better experience. And the quality, the looks, the device. So, it's everything I'm looking to it, into this vape lifestyle. So, it's a very pleasurable experience. And it's a very quality lifestyle, smoking vape. It's very quality." [P2]

Similarly, P6 enjoyed smoking, but because of the negative impact on his health he wanted to derive a similar feeling without as much harm.

"Yes. Just the sensation of smoking, I think it is. Because I like smoking, I just don't like the effects it has, unfortunately." [P6]

Others reported that the e-cigarette reduced some of the discomfort during their quit attempt but did not gain any pleasure or satisfaction from using it.

"Maybe it relieved a little bit of discomfort, but I didn't get the same satisfaction, like a cigarette does, no." [P6]

"Not really pleasurable, no. My friend, he really likes to blow those big clouds of smoke, and I just want the pain to go away." [P8]

Impulses

Theme 4: E-cigarette partially reducing urges to smoke

There were also mixed opinions on how effective an e-cigarette was at addressing urges to smoke. Several participants thought that an e-cigarette partially addressed urges to smoke, but ultimately were not able to fully displace them. P1 described vaping to be less satisfying than cigarettes, requiring more regular usage for the same hit of nicotine.

"I've found with vaping you're doing it constantly. If you can, you're taking puffs on a fairly constant basis. If you're just walking along the street, you're using it quite regularly. Whereas, with a cigarette, you would stop and go for a while. It's probably because it's a stronger, quicker hit. Whereas, with vaping, you need to do it constantly to have that satisfaction." [P1]

P5 mentioned that being able to vape removed the urge to purchase a pack of cigarettes. *"When I have the vape, the impulse to go out and buy a cigarette or to go out and buy a deck of cigarettes is evaporated or eliminated."* [P5]

P7 did not believe the JUUL satisfied his urges and said that he was generally smoking as much as he would usually despite using the device at the same time.

"It's difficult to say. I'm still smoking about roughly the same, perhaps one less, but it doesn't really satisfy the urge to smoke." [P7]

Internal stimuli

Theme 5: Mental health disrupting quit attempt

Poor mental health was described by four participants as a barrier to quitting smoking. The e-cigarette was not thought to be able to help some of these individuals cope in the same way that they believed cigarettes do.

"Then I wasn't even sure if it would be possible to smoke. I thought two days or so of not having had any, particularly at the moment, which is a difficult time. I would have liked to have said, right, let's just try and bite the bullet but it wouldn't have been feasible." [P1]

"I don't know. Like I said to you, recently, I've been under a lot of stress. Or in some way, it's a habit that has been when I got stress, I will roll a cigarette or roll a joint. Now, I am not sure that the vaping will compensate. But if one is in a stable mind or maybe more happy, I think one can actually... I could." [P4]

"I started [smoking] as a young kid. The stress I've been through and the stress I was going through when I came to this country as well, suffering from stress disorder. Nothing numbed my brain but the smoking. I'm still on medication till now because of that, but the cigarette is just the first thing you inhale, and it's really hard and it did help numb my pain, but for a short time, not for a long time." [P9]

External stimuli

Theme 6: Switching for family

Along with health and financial reasons, several participants went on to describe family responsibility as a primary reason for quitting smoking.

"Yes, because of my family, I stopped [smoking]. For this reason. For this particular reason. Because they are not happy with me. They are more worried because anything might happen to me. That's why I thought, I might as well make a change to my lifestyle, go to e-cigarette and it will be better for me to change everything in my life."

"I've just been through a really difficult time with death and dying. It wakes you up, makes you say, I've just finished caring for a very ill person, the last thing I want to do now is get sick myself. I'm saying the same thing with Sam, it's like now is our chance to live, so let's live." [P8]

Several participants described support from their family towards using the e-cigarette to stop smoking.

"Oh boy, my mum. My mum suffers from lung cancer and she doesn't smoke all her life. She never smoked, she never drank, and sometimes, the last couple of days or the last week she sees me, she's really pleased. They're supporting that, definitely." [P9]

"My family prefer that I use these [e-cigarettes] as opposed to smoking cigarettes, so most definitely, yes. The ashtrays and the smell and all those health indications. So, for my son and for me health wise." [P6]

5.5 Discussion

5.5.1 Summary

Comparisons between self-reported EMA data on e-cigarette usage with objectively recorded e-cigarette usage found the EMA to be a poor measure of recall of device usage among participants, for both the number of sessions with the device in a day, and the number of puffs taken in the most recent session. Different recorded patterns of e-cigarette usage during the early stages of a smoking quit attempt were evident among nine lower SEP smokers. Six participants had relatively stable patterns of usage over the study period. Three participants had fluctuating numbers of sessions each day, and used their devices more than the rest of the sample over the study period. There was also considerable variation within and between participants in the number of puffs per session on the Gram.

Participant interviews highlighted a variety motivational factors that may explain the variation in usage. All participants intended on persisting with an e-cigarette to support their current or future quit attempt. The primary reasons for quitting smoking with an e-cigarette were related to improving health and saving money, and in some instances due to a feeling of responsibility to quit for their family. There were mixed responses regarding e-cigarettes as a tool or a pleasurable activity, with some believing that they represented both and others perceiving the devices as a tool and nothing more. There were similarly mixed responses on how effective e-cigarettes were at suppressing urges to smoke cigarettes. Several participants described mental health that disrupted their ability to quit smoking. These themes highlight diverse ways in which e-cigarettes are viewed by lower SEP smokers, and the potential they have to support a smoking quit attempt.

5.5.2 Reliability of EMA surveys

The self-reported EMA surveys did not prove to be a reliable measure for estimating the number of sessions a user had on their device at the end of each day, or for estimating the number of puffs taken by a user during their most recent session. Unlike smoking, where there are definite starting and ending points (initiated by lighting of the cigarette and ended with stubbing it out), vaping has been described in previous studies as 'grazing'.[133] This involves using a device little and often over the course of a day (as was mentioned by some participants in this current study), making it challenging for a user to remember the number of puffs and delimit separate vaping sessions. Furthermore, different individuals may have different definitions of what a vaping session consists of. Although participants were informed of how a session was defined for this current study, in practice the concept of a session may be too abstract for each individual to be representative. Both in terms of ease of recall, and in the quantification of any harm from vaping, the volume of e-liquid consumed may be a more useful measure. Unfortunately, questions programmed into the EMA surveys related to e-liquid volume consumed were not answered by participants in this current study. As with the number of cigarettes smoked, the amount of e-liquid left in a bottle/cartridge is a simple visual method guiding recall. When combined with the self-reported number of sessions and or puffs on a device, the volume of e-liquid consumed may give a better indication of the intensity at which a user vapes. Consuming large volumes of e-liquid in fewer sessions, or with fewer puffs would suggest that the individual was vaping at a higher intensity. Albeit in a small sample, the poor survey response rate in this study raises a question on the extent to which SEP is associated with app-based survey participation.[278]

The utility of quantifying the harm from vaping is important and more accurate self-reported measures of usage will help achieve this. However, given continuous technological advancements in e-cigarettes, passively recording device usage will likely escape the confines of research studies and become more widespread among mass produced consumer devices, as is already evident with the JUUL C1. These objective measures of usage can offer greater accuracy and reliability than even well-designed self-reported surveys.[279] Furthermore, quantifying the harms from e-cigarette use should be placed in context with the harms from smoking cigarettes. Recent research has shown that vapers who use lower nicotine strength e-liquid consume more e-liquid than those on higher strengths and are exposed to higher levels of harmful carcinogenic carbonyl compounds.[280] However, when compared with the considerably higher levels of these same chemicals that a cigarette smoker is exposed to, the e-cigarette conferred exposure is substantially smaller. In this context encouraging lower SEP smokers who are more dependent on cigarettes to switch to lower harm e-cigarettes remains an important endeavour.

5.5.3 Usage and views towards e-cigarettes

Compared with the six participants with relatively stable patterns of sessions across the study period, the three individuals with fluctuating session patterns and who used their devices most frequently each day may have been more dependent on cigarettes. When deprived of cigarettes during the quit attempt, the erratic and frequent sessions on the e-cigarette may reflect self-titration of nicotine to compensate for the lack of smoking.[146] Other studies comparing e-cigarette usage patterns have shown that those using lower nicotine strength e-liquid consume more e-liquid compared with higher nicotine-strength e-liquid users who do not need to vape as frequently or intensely to receive the same does of nicotine from their device.[280] It is possible that the 18mg/ml nicotine strength e-liquid provided to the three likely more dependent participants in this current study was not sufficient to cover their usual dosage of nicotine from cigarettes. These individuals also mentioned experiencing symptoms of poor mental health during their interview, which along with its intersection with socio-economic disadvantage, is strongly associated with smoking and heaviness of smoking in the general population.[281]

In contrast, the two participants who had successfully quit smoking according to the criteria in this current study were the youngest and had been smoking for the fewest years. Session patterns for these successful quitters were more stable, and they both went several days without using their e-cigarette at all during the study period. Their ability to quit smoking in the context of this study may reflect lower dependence on cigarettes.

Variation in the number of puffs taken in each session is also likely a reflection of each user adapting to their device and attempting to find a pattern of usage that suits their individual need. Similar differences in usage among participants were apparent in a similar study conducted using earlier prototypes of the Gram device.[270]

All participants in this study expressed intentions to continue to use an e-cigarette either in future quit attempts or to maintain abstinence from smoking. With one exception, there was no expression of a desire to stop using an e-cigarette, which was universally thought to be safer than smoking cigarettes. Switching to an e-cigarette was felt to have considerable health benefits, with some participants perceiving immediate improvements in their respiratory symptoms during the study. Cost-savings were also regularly cited as a benefit of quitting smoking and using an e-cigarette, which is supported by evidence from population surveys estimating the average expenditure on e-cigarettes to be approximately one third of the expenditure of smokers.[245] Tax increases on the sale of cigarettes are known to be an equity-positive intervention to reduce smoking among socio-economically disadvantaged groups, who have less expendable income.[51] However, there remain some more dependent individuals within these groups who continue to smoke or rebound to alternatives such as roll-your-own tobacco[51], despite the increased expenditure and as a result suffer both continued harms and increased financial stress. Lower SEP smokers from this study highlighted their sensitivity to high cigarette prices and may therefore see a switch to e-cigarettes as a means to continue using nicotine without disrupting expenditure on necessities such as food, accommodation and health care.

In line with findings from recent ethnographic fieldwork in northern England[268], findings from this current study suggest that feelings of responsibility for family members permit e-cigarette use as a functional tool to quit smoking. Some participants mentioned support from family members for their use of the e-cigarette if it meant they were no longer smoking. Furthermore, several participants saw the devices not exclusively as a tool, but also as having a co-benefit of being an enjoyable activity.

Whether seen simply as a tool for smoking cessation, or for pleasure, the perceived health and financial benefits accrued following a switch to an e-cigarette, combined with feelings of responsibility towards their family to quit smoking suggest that disadvantaged and dependent smokers may see e-cigarettes as an acceptable and attractive cigarette replacement. This is despite scepticism as to how effective some individuals felt the devices are for replacing the need for a cigarette. E-cigarettes may present an affordable means to reduce exposure to harm and offer a better and more enjoyable option than other quitting aids or quitting without any assistance, which is an unlikely outcome among dependent smokers. Taken altogether these multiple factors may offer some explanation of the observed trend in Chapter 4, where e-cigarette use has increased year on year among long-term ex-smokers, and is more likely among lower SEP long-term ex-smokers compared with more advantaged groups.

Finally, several participants discussed experiencing periods of unstable mental health that disrupted their ability to maintain abstinence from smoking. Individuals with a mental condition are more likely to smoke, be heavy smokers and perceive greater difficulty in remaining abstinent.[281] Socio-economic disadvantage has been consistently associated with poor mental health, and this intersection presents a challenge for smoking cessation.[282] As described by participants in this current study, e-cigarettes alone may not always be sufficient for maintaining abstinence from smoking. In addition to e-cigarettes, addressing the socio-economic and psychosocial gradients in smoking and smoking cessation could be boosted by behavioural and pharmacological support at the individual level. Such support in addition to e-cigarettes is offered by stop smoking services in England and is the subject of the next chapter.

5.5.4 Limitations

This study should be interpreted in light of several important limitations. First, the completion rate of EMA surveys in this study was low. This prevented investigation of important measures, such as volume of e-liquid consumed and the number of cigarettes smoked each day during the quit attempt. Some participants provided responses to the survey questions, but there were missing data from the daily diary and recent session

EMA surveys. This meant that analyses were therefore restricted to what data were available, and may not necessarily reflect how the rest of the sample would have responded. The Gram EMA app has potential to be an effective delivery platform for surveys, but it was not used at the levels hoped for in this study. Unfortunately, interviews did not explore this further. The missing data made further analyses impossible, such as Bland-Altman plots and linear regression analyses to estimate how well changes in self-report device usage predicted changes in the recorded device usage.

Second, the method used in this study to obtain some measure of concordance between the EMA and device recorded data, the Cohen's kappa measure of agreement, does not indicate the distance between the incorrect answer and the objective measure. For instance, a response of 1-5 sessions per day when the true value was 15+ is less accurate than a response of 1-5 sessions per day when the true value was 6-10 sessions. A measure of raw self-reported usage would have permitted an estimation of agreement on a continuous scale, taking into account the distance between measurements (for example by using Bland-Altman plots).[283]

Third, data saturation was not reached after analysis of the nine interviews included in this study. Emergent themes that I have put forward must therefore be interpreted with caution as they would likely have changed with further interview data.

Fourth, the Gram devices gave some insight into usage patterns over the study period, but suffered frequent functional problems. All five devices that were being used in the study eventually could not connect to the Android app, and one device started to heat up the e-liquid even though the user was not puffing. It also remains possible that technical flaws influenced the low concordance between self-reported and device-recorded measures of sessions per day and puffs per session. For instance, apparently inaccurate self-reported estimates of usage may have in fact resulted from a failure of the device itself to record accurately. As a contingency measure, two JUUL C1 devices were purchased for use by the remaining three participants. However, use of the JUUL C1 currently requires manual extraction of data from the JUUL app, which would not be suitable for larger studies. Furthermore, the devices required more frequent charging than would be expected for other widely manufactured e-cigarettes. This reduces their utility as a smoking cessation tool as participants are not able to rely on them when they are away from an electrical supply during the day. The Gram device may be designed for less intensive use, rather than all-day nicotine vaping, and so the battery may not have been sufficient for the heavier nicotine users in this study. Some descriptions of device problems from participant interviews are outlined in Appendix 7.

Finally, although originally considered in earlier versions of the protocol, it was not possible to recruit a more representative sample of smokers that included those of higher SEP. This would have allowed for exploratory comparisons of device usage patterns and interview responses by SEP.

Notwithstanding these limitations, the study has some strengths worth noting with respect to highlighting the challenges inherent in conducting research related to health inequalities. At times there were difficulties in organising sessions and limited or unresponsive contact with participants. The recruitment rate was slow, with only nine participants enrolling over six months. Several individuals expressed interest but did not attend baseline sessions for study enrolment. However, this study has demonstrated that a sample of more disadvantaged smokers can be recruited through using local newspapers, albeit with higher advertising costs. To address challenges when conducting research with socially disadvantaged groups and increase their representation this study reiterates previous calls for the adoption of more flexible timeframes and higher resourcing costs to be successful.[278] Although suffering from functional problems, the Gram delivered some device-recorded usage data for comparison with self-reported measures. Future research that uses similar advances in e-cigarette technology can provide more granular real-time data for researchers to inform advice on smoking cessation and potential harm profiles of usage. Finally, although limited, the interviews with participants generated some useful initial perspectives on e-cigarette use from a disadvantaged sample and the initial results conform to research that has been conducted recently in this field. Nonetheless, because of the numerous limitations outlined above the findings should be considered exploratory, and may inform improved design and conduct of similar studies in future.

5.5.5 Future research

Future research should consider recruiting a larger sample size that is more representative of the smoking population in England, and employ Bluetooth enabled e-cigarette technology that has greater reliability when used by heavily dependent smokers in the context of a real-world smoking quit attempt. Such research could also use financial incentives to encourage better EMA survey completion, and provide portable charging devices to support use of the e-cigarettes provided. This would help prevent the large amount of missing data suffered by this current feasibility study, and better characterise patterns of dual e-cigarette and cigarette use during a quit attempt. Furthermore, while evidence for e-cigarettes as a smoking cessation tool in the general population is growing, there remains uncertainty about the effectiveness of the devices among disadvantaged and vulnerable populations of smokers.[267] More research conducted with disadvantaged smokers will help inform the design of equitable approaches to smoking cessation using e-cigarettes.

5.6 Conclusion

In conclusion, despite major limitations this mixed methods feasibility study observed different patterns of e-cigarette usage among lower SEP smokers during a quit attempt, with several likely more dependent smokers using an e-cigarette greater frequency and intensity than other participants who presented lower and more stable usage profiles. Comparisons between self-reported EMA data on e-cigarette usage with objectively recorded e-cigarette usage found the EMA to be a poor measure of recall of device usage among participants, for both the number of sessions with the device in a day, and the number of puffs taken in the most recent session. Interviews revealed that all participants intended on persisting with an e-cigarette to support their current or future quit attempt. Participants were trying to quit smoking with an e-cigarette to improve health and save money, and in some instances due to a feeling of responsibility to quit for their family. Some saw e-cigarettes as both a smoking cessation tool and a pleasurable activity, while others perceived the devices to be a tool and nothing more. Several participants described mental health being a limiting factor disrupting their ability to successfully quit smoking. For e-cigarettes to be a successful replacement of cigarettes, they need to displace the perceived enjoyment of smoking, address the cue-driven impulses that have been developed over time and attenuate withdrawal symptoms that occur following smoking cessation. Participants in this study have suggested that e-cigarettes can support some of these factors, which highlights the potential that these devices have towards supporting more heavily dependent lower SEP smokers to quit smoking. However, given the challenges that more disadvantaged smokers face (section 1.1), long-term effectiveness for smoking cessation could be improved by providing the device alongside professionally delivered smoking cessation support and medication. Chapter 6 presents the qualitative component of a process evaluation of such a study, where e-cigarettes are provided to smokers in addition to standard support at local authority stop smoking services in England.

Chapter 6

The acceptability of e-cigarettes in addition to varenicline and behavioural support among socio-economically disadvantaged clients at stop smoking services (Study 5)

Abstract

Little is known about what clients from lower socio-economic backgrounds think about the offer of an e-cigarette alongside varenicline and behavioural support at stop smoking services (SSS) in England. As a component of an ongoing randomised controlled trial process evaluation, this qualitative study aimed to explore this among a socio-economically disadvantaged sample by using the theoretical framework of acceptability (TFA) and the capacity, opportunity, motivation, behaviour (COM-B) model to systematically identify 1) whether the E-ASSIST intervention was acceptable to participants, and 2) any potential barriers and enablers to participation. Interviews were carried out with ten lower socio-economic position (SEP) participants enrolled in the

intervention (e-cigarette) arm of the trial between July 2019 and February 2020. Discussions were conducted using a topic guide structured around the TFA and COM-B frameworks. Responses were audio recorded, transcribed verbatim and first deductively coded into domains of the TFA and COM-B. Then, inductive thematic analysis generated themes within the domains of each theoretical framework. In terms of acceptability of the intervention, participants had positive affect towards their SSS advisor (TFA component: *Affective attitude*) despite the burden of attending regular sessions at the SSS and adhering to prescription medication (*Burden*). Negative perceptions towards nicotine use discouraged e-cigarette usage in the long term and influenced mixed opinions on whether SSS should provide them (*Ethicality*). The intervention package was thought to be complementary (*Intervention coherence*), with Champix primarily reducing urges to smoke and the e-cigarette replacing the habitual nature of smoking (*Perceived effectiveness*). In terms of enablers to participation, e-cigarettes were found to be cheaper than smoking and more flexible to use (COM-B component: *Physical opportunity*), were thought to be a useful to replace the habit of smoking (*Automatic motivation*) and were a useful back-up to prevent relapse (*Reflective motivation*). Support from family was a key driver of participants' attempt to quit (*Social opportunity).* The perceived harshness of vaping (*Psychological capability*) may be a barrier to device usage at the early stages of the quit attempt. Overall, e-cigarettes combined with support and medication delivered at SSS were deemed to be acceptable among a sample of lower SEP participants. The main enablers to participation fell within the opportunity and motivation domains of the COM-B framework. The main barrier was categorised under the capability domain, but several others overlapped with themes under domains in the TFA, including difficulty in attending regular sessions (*Physical opportunity*), and concerns that use of an e-cigarette represented replacing one addiction with another (*Reflective motivation*)**.**

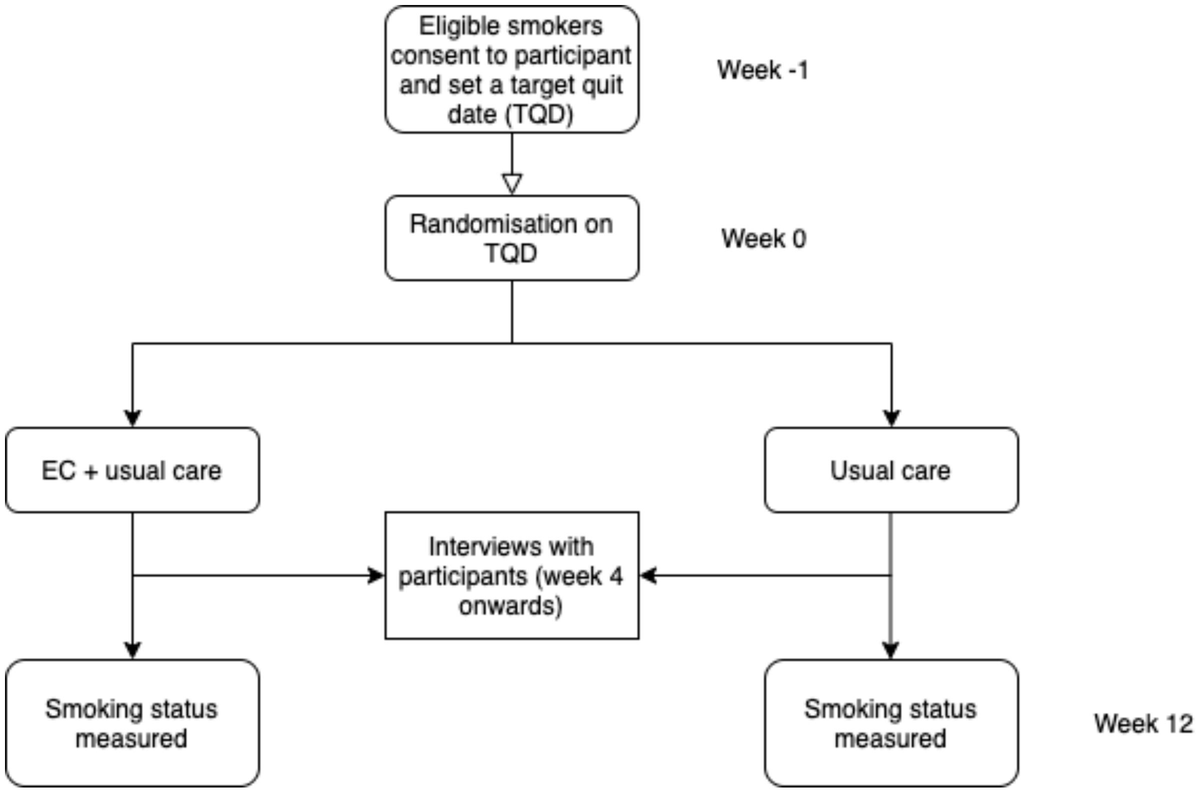
6.1 Background

6.1.1 The E-ASSIST RCT

As discussed in previous chapters, e-cigarettes deliver nicotine and simulate some of the sensory and behavioural aspects of smoking, and as such may support quit attempts in smokers who are otherwise unable or unwilling to quit. Chapter 5 suggested that e-cigarettes are perceived by some to have both health and financial benefits, and to be both a smoking cessation tool and a pleasant activity. Despite this, greater cigarette addiction and/or socio-environmental influences continue to make quitting smoking a challenge among more socio-economically disadvantaged smokers. For these smokers, specialist individual-level behavioural support and pharmacotherapy may offer extra support and complement the effects of an e-cigarette. The availability and rise of e-cigarettes as a consumer product appears to be contributing to the overall decline in smoking in England at the population level[140], and high-quality RCT evidence shows their effectiveness within stop smoking services (SSS)[138], which deliver individual-level behavioural support to many socio-economically disadvantaged smokers (see Chapter 2).[113]

The "e-cigarettes to augment stop-smoking in-person support and treatment with varenicline" (E-ASSIST) study is an ongoing pragmatic RCT taking place at local authority SSS in London and the surrounding region in England.[284] Dr Lion Shahab is the principal investigator for this trial, I am co-leading the trial with Harry Tattan-Birch, a PhD student in the UCL Tobacco Alcohol Research Group. The aim of E-ASSIST is to assess whether the offer of a third-generation e-cigarette starter kit, in addition to usual care provided by SSS practitioners, improves quit success (from weeks 9-12 after study enrolment – see figure 6.1) among smokers attending the SSS compared with usual care alone. Usual care in this context is limited to a prescription for the nicotine-receptor partial agonist varenicline (see section 1.5.2.2) and behavioural support delivered by a trained smoking cessation advisor.

Figure 6.1: Study flow diagram



The combination of a nicotine delivery device such as an e-cigarette with varenicline (a partial nicotinic acetylcholine receptor (nAChR) agonist may appear counterintuitive. However, as described previously, partial agonists of nAChRs display concurrent agonist and antagonistic properties[100], both influencing and blocking dopaminergic pathways associated with pleasure and withdrawal symptoms from nicotine use.[97] It is possible that the α4β2 nAChR reception subtype, (an important mediator in nicotine addiction) is not fully saturated by varenicline, and as such the additional nicotine delivered by an e-cigarette may bind and increase receptor activation. While targeting the $\alpha4\beta2$ nAChRs in the brain with a partial agonist may attenuate both nicotine craving and withdrawal symptoms in smokers attempting to quit, additional nicotine provided by e-cigarettes may bind to other important nicotine receptors not targeted by varenicline, which might explain why combination therapy of varenicline with NRT is better than varenicline alone.[285] Besides the pharmacodynamics, there may be additional benefit from e-cigarettes delivering nicotine by a hand-to-mouth behaviour reminiscent of smoking a cigarette.

Another reason for the trial relates to SSS circumstances. Usage of the services by smokers is low[286] (less than 5% of quit attempts in the past year[131]) and the services are facing further funding cuts.[76] The offer of e-cigarettes to augment treatment approaches could potentially increase the appeal and improve cessation rates.

E-ASSIST is taking place at eight SSS, with the following participant eligibility criteria:

- Age 18+
- Smoker
- Attending one-to-one specialist support in London local authority SSS.
- Proficient in English
- Have set a target quit date
- Choose to use varenicline (Champix) to support their quit attempt
- Willing to try e-cigarettes

Women who are pregnant or breastfeeding are excluded from participating. The general study procedures are outlined in table 6.1.

Table 6.1: E-ASSIST RCT Study procedures

Pre-Quit Session	The SSS practitioner will describe the study and go through the information sheet. The participant will then have the opportunity to ask any questions before being asked to sign a consent form to show that they have agreed to take part. Participants will be asked to fill out a short questionnaire regarding details about themselves, their smoking history, their current smoking behaviour and past medication use. The amount of carbon monoxide (CO) in their breath will also be measured. The SSS practitioner will provide usual care to participants, discussing with the participant how best to stop smoking and advise them on withdrawal symptoms, available pharmacological support and how to use it, provide them with a prescription to obtain pharmacotherapy for a prescription charge or free of charge, and set a target quit date.
Target Quit Date (TQD)	Participants will be randomised to receive either: - Usual care (varenicline together with behavioural support) alone **OR** - Usual care plus an offer of a free third generation e-cigarette starter kit with a four-week supply of e-liquid and brief advice on e-cigarette use. Practitioners will give participants further support about how best to stop smoking and remain abstinent and be provided more information on varenicline use. Participants will be asked to stop smoking after this session. If participants are provided with an e-cigarette, they will be encouraged to start using it from your target quit date onwards.
	Participants will be asked to return for weekly or fortnightly sessions as per standard SSS practice to monitor their progress and to receive further counselling and support. Their smoking status will be recorded at all sessions after TQD (if not in person then by telephone). If they self-report abstinence, then participants will be required to blow into a machine that

Weeks 1-12 post TQD	measures the amount of carbon monoxide in their breath in order to verify smoking cessation. If the participant was provided with an e-cigarette (intervention group), e-cigarette use will be recorded. If participants have run out of e-liquid they will be encouraged to seek out local vape shops to obtain further e-liquid, suited to their individual needs and flavour preference. Interviews will be conducted with participants in the e-cigarette arm of the trial from week 4 post TQD.

6.1.1.1 RCT SSS service and participant recruitment

Eligible participants are being recruited by participating SSS as part of their standard programme for smoking cessation. Recent service data across 33 London local authorities indicated that >10,000 (~300 per authority), receive one-to-one specialist support with varenicline, and set a target quit date (TQD) each year.[286] Using an estimate where less than ~50% of eligible participants consented to participate in the trial, a target was set to involve eight SSS each with a recruitment rate of 8 participants per month. This was considered to be sufficient to recruit the required number of participants (n=1,266) within a 20-month period. I proactively recruited SSS during 2018-2019, with initial piloting of the RCT commencing at a service in Cambridgeshire in 2019. As of February 2020, eight services had agreed to participate and had started recruiting participants (Table 6.2). Trained specialist stop-smoking advisors deliver their programme of behavioural support at several locations both in the community (at council offices, libraries and community centres) and at NHS sites (including GP clinics and Hospitals in the local borough).

Ethical approval was gained from both the UCL research ethics committee (8323/003 and the NHS research ethics committee (REC reference: 19/LO/0239) before study commencement in 2019.

Table 6.2: E-ASSIST RCT Participant recruitment

SSS	Number of participants recruited
Bexley	45
Cambridgeshire/Waltham Forest	6
Croydon	0
Hackney	11
Leicester	2
Lewisham	27
Tower Hamlets	4
TOTAL	95

*As of May 2020. Cambridgeshire/Waltham Forest are included together because the SSS is delivered by the same provider (Everyone Health)

6.1.1.2 Disruption due to the COVID-19 pandemic in England

Due to the shutdown of activities and social distancing measures mandated by the UK government in response to the COVID-19 epidemic, recruitment for the E-ASSIST RCT was paused on March 14th, 2020. The trial is expected to resume when current lockdown restrictions mandating social distancing measures are lifted and after conversation with all members of the E-ASSIST research team, trial steering committee and participating stop smoking services.

6.1.2 Acceptability of the E-ASSIST intervention and barriers and enablers to participation

The content, quality and context of an intervention that participants receive determines how acceptable they find it. This in turn influences how likely they are to adhere to treatment allocations and to benefit from improved outcomes. Acceptability is therefore recognised as an important consideration of health care interventions.[287] However, only recently has a systematic theory emerged on how to define or assess acceptability. One such theory is the theoretical framework of acceptability (TFA), which posits acceptability as a multi-dimensional construct reflecting the extent to which people providing or receiving an intervention believe it to be appropriate, based on experienced or anticipated cognitive and emotional responses to it. The TFA consists of seven constructs: affective attitude, burden, perceived effectiveness, intervention coherence, opportunity costs, and self-efficacy (see Table 6.3 in the analysis section 6.2.4 for more information).

The E-ASSIST smoking cessation intervention includes behavioural support. This support typically involves several behavioural change techniques (BCTs) such as goal setting, coping planning, social support and advice on medications. Participants are required to adhere to a regime of medication and attend regular sessions with their advisor, which may be challenging for some participants. Stop smoking advisors within and between services may deliver BCTs differently. The use of e-cigarettes varies between individuals in terms of flavour and nicotine preferences, and also in how they may view the devices for a smoking quit attempt. Together these factors may interact to influence the overall intervention outcomes.

As described in Chapters 3 and 4, my findings from the Smoking Toolkit Study (STS) in England indicated that although there was no clear socio-economic patterning in e-cigarette use during a quit attempt, there was a social gradient among long-term (>1-year) ex-smokers whereby respondents from more disadvantaged socio-economic groups were more likely to use an e-cigarette compared with those from more advantaged groups.[253] Given that the E-ASSIST RCT is being conducted across multiple services that have target populations with different socio-economic characteristics the aim of this current chapter, was to apply the TFA[287] to explore the acceptability of the e-cigarette intervention among socio-economically disadvantaged participants. As aforementioned, the TFA postulates acceptability as a multi-dimensional construct reflecting the extent to which people providing or receiving an intervention believe it to be appropriate, based on experienced or anticipated cognitive and emotional responses to it.

The 'capacity, opportunity, motivation, behaviour' (COM-B) model, nested within the wider Behaviour Change Wheel framework, states that a given behaviour is the outcome of an individual's capacity to perform it, opportunity to take part in it and the motivation to engage with it. In order to change a behaviour, at least one of capability, opportunity and motivation must change (Table 6.4 in section 6.2.4). The COM-B model has been applied in several contexts, including smoking cessation,[288] to understand barriers and enablers to health behaviour and service use.[70,288,289] By providing a framework for analysis of participant responses to and interaction with the intervention, the COM-B model can help understand potential mechanisms of change (the ways in which the intervention brings about changes in behaviour) and elucidate key influences on participation, which in turn influence smoking cessation outcomes. It was therefore applied in the current E-ASSIST process evaluation to investigate specific barriers and enablers for smokers that affect participation in the intervention, with a specific focus in this study on the perspective of lower SEP participants.

This study included participants from socio-economically disadvantaged backgrounds for several reasons. It is well understood that tobacco smoking rates are highest in this group[26] and that lower SEP individuals also face more barriers to quitting smoking (Chapter 1). Specialist support may help overcome some of these barriers, and as discussed in Chapter 5 an e-cigarette may be an attractive and effective tool to participants and improve the likelihood of smoking cessation. In addition, Chapters 2 and 3 have highlighted that at the population-level there is a social gradient among long-term ex-smokers whereby respondents from more disadvantaged socio-economic groups were more likely to use an e-cigarette compared with those from more advantaged groups.[253,290] This is relevant in this study as it was Chapter 5; how individuals perceive the devices in their quit attempt may influence longer-term usage.

Finally, exploring acceptability and barriers and enablers to participation in the E-ASSIST intervention among a lower SEP sample is important because it can inform understanding of the current UK SSS model when combined with the offer of e-cigarettes from the perspectives of treatment-seeking lower SEP smokers.[291] This in turn may inform the iteration of equity-positive alternative smoking cessation support services involving the use of e-cigarettes. Indeed, although stop smoking services may be equity positive when targeted at deprived communities[115] (Chapter 2), there is little data on how an e-cigarette intervention would be received among more socio-economically disadvantaged participants that attend SSS. Acceptability of the e-cigarette intervention and barriers and enablers (in terms of capability, opportunity and motivation) to participation might be different among lower SEP smokers compared with more advantaged smokers. For instance, due to variable working hours and less time to attend SSS sessions (opportunity), varying levels of education related to the harms of e-cigarettes relative to smoking (capability), certain values and perceptions towards nicotine use (motivation), and having less expendable income.

Overall, this study exploring acceptability and barriers to enablers to participation may help interpret the outcomes of the trial, inform intervention refinement (if acceptability is low, or if there are barriers and enablers to be acted upon to improve the intervention), and if shown to be effective to inform future roll-out and scalability of the intervention across SSS at the national-level.[292]

Therefore, this qualitative component of the E-ASSIST process evaluation sought to answer the following research questions:

1) What is the acceptability of the E-ASSIST intervention among lower SEP participants enrolled in the RCT?
2) What are the barriers and enablers to participation in the in E-ASSIST intervention?

6.2 Methods

6.2.1 Acceptability and barriers and enablers of the E-ASSIST intervention

Semi-structured interviews using a flexible topic guide (Appendix 8) were carried out with purposively recruited participants from lower-SEP backgrounds after they had passed the 4-week follow-up timepoint. These interviews assessed the acceptability of the e-cigarette intervention using the TFA, and barriers and enablers using the COM-B model.

6.2.2 Sample and recruitment

Eligible participants from two participating SSS were identified as per the E-ASSIST RCT methods described in section 6.1. Opportunity sub-sampling purposively recruited participants of more disadvantaged SEP, who were in the intervention (e-cigarette) arm of the trial, and who had been enrolled in the trial for at least 4 weeks. Occupation was operationalised as the measure of SEP using the National Readership Survey measure of social grade.[248] Lower SEP was defined as those in categories C2, D or E (skilled manual workers, semi-skilled and unskilled manual workers, state pensioners, causal and lowest grade workers, and unemployed with state benefits only). The study aimed to recruit an initial sample of 10-15 participants with a stopping criterion once interviews appeared to have reached data saturation (see section 6.2.4).[293] In thematic analysis, data saturation is defined as the point at which no new themes or codes emerge from the interview data. However, following the aforementioned pause of the study due to the COVID-19 epidemic in England, which included a scale-back of the in-person service provided by SSS, I was unable to recruit more than 10 participants. This meant that the initial method of assessing data saturation was incomplete. Ideally, data from an 11th participant would have been analysed, and if new themes emerged, further interviews would have been required and data saturation reassessed in a systematic manner. If no new themes emerged then data saturation would have been achieved.[294] Despite not being able to recruit further participants, I nonetheless conducted a data saturation assessment (Appendix 8, Table A6.1), wherein themes and interviews were tabulated, with a row for each theme and with each column representing each participant interview. No new emerging themes were identified after analysing the initial 10 participant interviews, and although it was not possible to interview an 11th participant it appears likely that data saturation had been achieved (Data saturation in Appendix 8).

6.2.3 Materials

6.2.3.1 Topic guide

The interview topic guide was split into two sections. The first section was based on the TFA, and the second section was based on the COM-B framework (Appendix 8). Each section was structured around the domains of the respective framework and included at least one question from each domain. Examples of the types of question in each domain within the topic guide are presented in Tables 6.3 and 6.4. The interview topic guide was semi-structured, where a fixed set of topics related to each theoretical domain were covered but with flexible ordering and freedom to prompt the participant with follow-up questions. The topic guide was iterated following pilot interviews with Harry Tattan-Birch (HTB, a PhD student at UCL), and with one study participant who was not audio-recorded and whose data were not included in the current analysis.

6.2.4 Data collection

Interviews were carried out with participants once they had completed the 4-week post target quit date follow-up. I conducted nine interviews and HTB conducted one interview. Four interviews were conducted in-person at the SSS, and six were telephone interviews. Participants were provided with an information sheet and had provided written consent to participate in the E-ASSIST trial and the associated process evaluation. All interviews were audio recorded. I transcribed the first five interviews to familiarise myself with the data. The remaining transcripts were anonymised so no individual or stop smoking service was identifiable, before being sent to a university approved transcription agency (Way With Words ltd.). After checking over the transcribed interviews, all associated audio recordings were deleted.

6.2.5 Analysis

All interview transcripts were combined into one complete dataset for the analysis in NVivo version 12. A combination of deductive and inductive thematic framework analysis using the TFA was conducted on transcripts of interviews with participants and investigated how more socio-economically disadvantaged participants receive and respond to the e-cigarette intervention and explore reasons why they respond to it in the way they do.

Firstly, I read transcripts repeatedly to become familiar with the whole data set. Then using a deductive framework based around the TFA, I deductively coded participant responses into the TFA domains they were judged to best fit under (Table 6.3). For example, the participant response “Most people would just give up going [to the SSS] by now because it's a pain in the backside to be honest, they're not making it easy." was coded under the TFA domain *Burden*.

Following this, the same process of deductive-inductive thematic analysis was conducted using the COM-B framework for behaviour change. For instance, under the COM-B framework a participant response of "With the e-cigarette instead of having to go and physically have a fag, you could just have a puff on it whenever you fancied needing one, so it gave you the hit whenever you wanted it, really." was coded under the domain *Physical opportunity*. Where appropriate, it was possible to assign a response to more than one TFA and/or COM-B domain. For example, "I just don't know, if it's like my mum's doing the Nicorette for years and gave up smoking for years, so it's like [the e-cigarette is] literally substituting it, it's not really getting rid of that habit or addiction." was coded under both *Ethicality* (TFA) and *Reflective motivation* (COM-B).

Table 6.3: The Theoretical Framework of Acceptability

TFA domain	Definition	Example quote
Affective attitude	The feelings that individuals have about the intervention	"[SSS advisor] was really good. She encouraged me to obviously carry on quit smoking. I was doing a really good job, I had stopped smoking, and her support, cheering me on every fortnight, it was the intention not let her down as well." [P7, M]
Burden	The perceived amount of effort that is required to participate in the intervention	"Most people would just give up going [to the SSS] by now because it's a pain in the backside to be honest, they're not making it easy." [P9, F]
Ethicality	The extent to which the intervention has good fit with an individual's value system	"But what you're doing is giving someone who is addicted to nicotine, nicotine, which I don't understand. Am I happy that doctors prescribe nicotine to smokers? The answer would be no." [P9, W]
Intervention coherence	The extent to which the participant understands the intervention and how it works	"The vape is quite physical, and then the Champix is the craving, and obviously the support is to keep you encouraged, to carry on,

		to help you feel encouraged." [P10, F]
*Opportunity costs**	The extent to which benefits, profits, or values must be given up to engage in the intervention	"I gotta stop eating, because you tend to eat more when you give up smoking." [P3, F]
Perceived effectiveness	The extent to which the intervention is perceived to be likely to achieve its purpose	"I think [Champix] that's the one and only actually that will stop you smoking. I'm almost certain it is. [P2, M]
*Self-efficacy**	The participant's confidence that they can perform the behaviour(s) required to participate in the intervention	"I was hopeful. Even now I still want a cigarette, it hasn't taken it away. I don't know, I'm hopeful that I can get there in the end." [P6, M]

*Data coded into these domains did not necessarily lead to the emergence of a summary theme as a result.

Table 6.4: The COM-B framework

COM-B domain	Definition	Example quote
Automatic motivation	Feelings and impulses that affect participation in the intervention	"The EC is like a backup. That's how I use them anyway, I don't use them all the time. But on days when you are quitting and you feel the craving." [P1, M]
Reflective motivation	Self-conscious decision making and reasoning that influence intervention participation	"To be truthful I mean I've smoked for so many years, it's sort of inbred, it's me. Everyone knows, I mean they can't believe I'm giving up smoking again. But I don't wanna be a non-smoker but then a vape addict." [P4, F]
*Physical capability**	Having the physical skills to participate in the intervention package	"But you've got to be careful using that thing. You give yourself a double dose of that, buggaroo, oh dear, that is not on." [P2, M]
Psychological capability	Having the knowledge and capacity to participate in the intervention.	"Considering how much I use it [the e-cigarette], it's lasted pretty long. I'm not sure, but I put it on the lower coil, so maybe that's why it's not burning as much, but it's

		lasting quite a while so that's good." [P10, F]
Physical opportunity	Environmental factors that enable participation.	"I can use the e-cigarette indoors. Because it's not actually smoking is it? It's just a vapour in a way." [P2, M]
Social opportunity	Social factors that enable or prompt intervention participation	"My daughter, she don't mind me on the e-cigarette. She says I'm much better without smoke. I'm better off with the e-cigarette than I am with a packet of cigarettes." [P2, M]

Following this deductive process, an inductive thematic analysis was carried out to generate overarching themes within each respective TFA or COM-B domain for responses with similar underlying beliefs and ideas. A similar methodology has been used for work using the Theoretical Domains Framework, a more granular version of the COM-B model.[295] This involved grouping together similar responses coded to each domain, and inductively generating a theme label, which summarised the shared meaning between the responses. For example, the responses "The pros [of using an e-cigarette], it's just trying to break the habit of that cigarette from hand to mouth. Yeah with me it's just that habit." and "Sucking an e-cigarette, it mimics what you would do if you were having a cigarette" were grouped under the theme label *Replacing the habit of smoking* in the TFA domain *Burden.*

Five (50%) of transcripts were read and double coded by HTB to promote reliability. We met to discuss and compare our independent coding until a set of codes were agreed upon (the theme label reflected the shared meaning of different quotes assigned to that domain).

6.3 Results

A total of ten E-ASSIST participants from the intervention (e-cigarette) arm of the study were recruited (Median age 54.5, range = 28-70; 50% women). Participant characteristics are summarised in Table 6.5. Interviews lasted a median of 23.5 minutes (range 17-41).

Table 6.5: Participant characteristics

Participant	Age	Sex	Years smoked	Occupation*
1	56	M	45	Routine/manual
2	70	M	52	Retired
3	54	F	32	Administrative
4	60	F	45	Administrative
5	55	M	46	Skilled manual
6	67	M	58	Retired
7	44	M	26	Administrative
8	35	F	20	Routine/manual

9	43	F	30	Administrative
10	28	F	13	Routine/manual

Sex: M = Male, F = Female; *Occupation categorised according to the NRS classification of social grade based on occupation.

6.3.1 Themes

All themes are presented within the TFA or COM-B domain that they relate to. A more detailed coding matrix is available in Appendix 8. Themes were not identified for all domains in each respective theoretical framework, and these domains are not listed in the results section. Summary Table 6.6 and Table 6.7 each outline the domains from each framework into which interview data was coded, the number of themes identified within each of these domains, and the number of participants represented in each theme. Commonality between themes across the two theoretical frameworks occurred on several occasions. Any such overlap generated under different TFA or COM-B domains is covered in the discussion section 6.4.2.

6.3.1.1 Acceptability of the E-ASSIST intervention (TFA)

Table 6.6: TFA theme summary table

TFA Domain	Number of themes	Number of participants per theme
Affective attitude	1	10
Burden	2	8
		5
Ethicality	2	8
		8
Intervention coherence	1	10
Perceived effectiveness	2	7
		8

*Domains not listed are those under which no themes emerged

Affective attitude

Positive affect for SSS advisor

All participants voiced positive feelings towards their stop smoking advisor. This affect reflected the supportive relationships forged by the advisor with their client, and the personal understanding of the difficulties they faced when trying to quit smoking. These feelings were mentioned despite the other challenges inherent in engaging with and travelling to the SSS, as described in the themes below.

"[SSS advisor] was really good. She encouraged me to obviously carry on quitting smoking. I was doing a really good job, I had stopped smoking, and her support, cheering me on every fortnight. It was the intention not to let her down as well." (Participant 7, Male)

"[SSS advisor] talks to you like she knows exactly what she's going on about, and the dips and the highs and the lows". (Participant 9, Female)

Within the *Affective attitude* domain of the TFA, this theme indicated high acceptability for the behavioural support component of the E-ASSIST intervention.

Burden

Difficulties with SSS care pathway

The effort required to travel to regular appointments was highlighted by eight participants. This physical distance represents a potential barrier to study participation for those less motivated to make the journey, or who have competing priorities in their lives.

"*When I rung them and they said, oh, you've got to go to this appointment and you've got to do this and that, I thought, really? It sounded like no one was making it easy to give up smoking. Because I work full-time, so I've got to go to meet somebody, you get a bit of paper, to go back to my doctor, to go from my doctor to the chemist within 48 hours, you just think, why can't I just go straight to my doctor and get the prescription?"* (Participant 9, Female)

"It's every week, once a week, and then I've got baby, so I have to walk up there. We walked up there, and it was pouring with rain the other day. I missed one because I just couldn't get up there. I don't drive, I live on the second floor. If I'm out I have to rush back and get a bus, so it is a chore to have to go." (Participant 10, Female)

Within the *burden* domain of the TFA, this theme indicated low acceptability for attendance at SSS as part of the E-ASSIST intervention.

Side-effects from Champix

The prescribed pharmacotherapy required effort in terms of adherence to the daily regimen, and also in dealing with potential side-effects that the medication was perceived to be causing.

"I felt sometimes I get a sick feeling. But that's early in the morning. I don't know if that's because I haven't eaten anything. But definitely if you cheat you do feel rough as hell, normally. I've done that a few times, I've cheated, and you do regret it." (Participant 1, Male)

One participant reported a reduction in the dosage of Champix in response to these side-effects.

"I must admit they do make me nauseous. I'm not taking two a day. I can't. They make me feel quite sick. And on the odd occasion I have been sick. So, I'm just taking one a day. [SSS advisor] is actually, this next prescription or the last prescription I had, he's reduced the milligram down, so I'll be able to take the two a day. Yeah. Because I can't. It makes me feel so ill, truly." [Participant 3, Female]

Within the *Burden* domain of the TFA, this theme indicated lower acceptability for the pharmacotherapy component of the E-ASSIST intervention.

Ethicality

E-cigarette replaces one addiction with another

Eight participants reflected on the fact that e-cigarettes do not alleviate their dependence on nicotine after they had quit smoking. This continued dependence was frequently described by participants as replacing one addiction with another, and that this did not fit in with their values towards quitting smoking. However, despite this value judgement, several participants acknowledged the benefit that the devices confer for quitting smoking.

"But now they tend to smoke the e-cigarette constantly, so they seem to be addicted to that rather than addicted to cigarettes, which is obviously supposedly better. But it drives me mad that they've got an e-cigarette because to me I think it's not real, why are you smoking it?" [Participant 6, Male]

"Because I see it as an addiction as well. That's why I try and only use it when I need it, you know what I mean? Because I feel you're replacing one addition with another. That's how I see it." [Participant 1, Male]

One participant held strong views against providing someone with a nicotine containing e-cigarette for their smoking quit attempt and recommended that the devices are not made available at health services.

"But what you're doing is giving someone who is addicted to nicotine, nicotine, which I don't understand. Am I happy that doctors prescribe nicotine to smokers? The answer would be no." [Participant 9, Female]

Within the *Ethicality* domain of the TFA, these mixed responses highlight both high and low acceptability towards the e-cigarette component of the E-ASSIST intervention.

Divergence of opinion on providing an e-cigarette as part of SSS offering

Differing views were expressed between participants as to whether e-cigarettes should be offered as part of the SSS programme of support. Four participants argued that because the cost of using an e-cigarette is cheaper than smoking cigarettes, the money saved from smoking could be used by individuals to purchase their own device instead of being given one for free by a government funded SSS.

"Well, probably yeah, I think people would not necessarily get them for free. I probably don't agree with that because they only cost 10-15 quid and you're gonna save that in what you're not smoking anyway." [Participant 1, Male]

"Probably not, because if you want this, they are not expensive are they, and if you're saving all that money on cigarettes, then you can afford to buy one. I mean if this [e-cigarette] breaks, I'd go get myself another one the same." [Participant 4, Female]

Other participants believed that it was a good thing for SSS to provide e-cigarettes. A successful experience of using the devices in supporting their quit attempt informed their encouragement for making e-cigarettes available to other smokers attending SSS, who would also experience the same benefits as a result.

"It's a good thing because it's helped me stop, so it would help other people stop. Especially some of the younger generation that are trying to get off cigarettes and stuff, as e-cigs are so trendy now, you get so many flavours out there, it will help a lot of the younger generation break free from smoking." [Participant 7, Male]

"If it's gonna help you pack up, like I said the first two or three weeks, or four weeks, then I think it's a good idea." [Participant 2, Male]

One participant thought that e-cigarettes should be offered, but not provided universally to all clients attending SSS. He believed that people held different concerns and opinions towards the devices, and that some individuals may not be accepting of their use for smoking cessation.

"I think it does depend on the individual. Because it's not for everyone. People have their reservations. You know, whether it's a little bit of bad press that one blew up. There are many different flavours. I think it depends on the individual. But being that I have now got the hindsight that I've used it and it's helped. I'd say give it to everyone. Offer it for everyone. Not give it. Offer it to everyone. It's your choice. It does help." [Participant 5, Male]

Within the *Ethicality* domain of the TFA, the divergent opinions expressed in this theme indicated both low and high acceptability for the e-cigarette offer as part of the E-ASSIST intervention at SSS.

<u>Intervention coherence</u>

Complementary nature of intervention package

All participants thought that the combination of the different components of the intervention made sense as an overall package of support. Together, the behavioural support, pharmacotherapy and e-cigarette were deemed to be complementary to one another. The Champix was felt to reduce cravings to smoke and worked with the e-cigarette which acted as a back-up, helping to substitute the habit of smoking. The behavioural support from SSS advisors completed the package by offering guidance and encouragement through the quit attempt.

"The vape is quite physical, and then the Champix is the craving, and obviously the support is to keep you encouraged, to carry on." [Participant 10, Female]

"Yes, it did, very much so. The Champix is the blocking thing, which has worked. [SSS advisor] does give me the support I needed, which gave me the encouragement I needed when I was like "what am I doing this for?" sort of thing. The e-cigarette is like a backup. You get to the point where you go "I just want a cigarette, I'm just going to have one, but, no, I'll have this instead." It's just that last little bit that you needed to finish it off, so they work really well together". [Participant 6, Male]

Within the *Intervention coherence* domain of the TFA, this theme suggested high acceptability for the combined package of support in the E-ASSIST intervention.

Perceived effectiveness

Champix effectively reduces urges to smoke

Although participants displayed different levels of knowledge about how Champix worked, seven felt that the medication was effectively reducing or stopping their urges to smoke a cigarette. It was frequently regarded as the most effective component for smoking cessation in the treatment package.

"My understanding is on a personal level, what I think is really striking to me is that it stops the receptor. It stops the receptors in your brain. And it stops that feeling dead. I don't know what it does in the brain. with the receptors and the messages that get sent from your synapses that says that you want a cigarette. I don't know what it does up there but it's definitely doing something. And it's stopped me wanting a cigarette, it stopped that urge." [Participant 5, Male]

"The urges, they slowly go within the first three weeks. They get less and less. And you don't want a cigarette." [Participant 2, Male]

The same participant mentioned that the taste and urge to smoke were no longer present, but he still found himself lighting a cigarette out of habit, before discarding it.

"After your first week, you didn't worry about a cigarette. And if you lit a cigarette, you'd fling it. It just didn't taste nice in your mouth. Then the second week was quite good because then I wasn't bothered about anything and I had other interests as well." [Participant 2, Male]

Within the *Perceived effectiveness* domain of the TFA, this theme suggested high acceptability for the pharmacotherapy component of the E-ASSIST intervention.

6.3.1.2 Barriers and enablers to E-ASSIST intervention participation (COM-B)

Table 6.7: COM-B theme summary table

TFA Domain	Number of themes	Number of participants per theme	Barriers	Enablers	Mixed
Automatic motivation	1	8		X	
Reflective motivation	2	7 6		X	X
Physical capability	1	6	X		
Physical opportunity	2	8 6		X	
Social opportunity	1	6		X	

*Domains not listed are those under which no themes emerged

Automatic motivation

Replacing the habit of smoking

The e-cigarette was believed to act as an effective substitute to smoking by suppressing the immediate need for a cigarette and by replacing the feeling of having a cigarette in your hand. Several individuals mentioned using their device at times when they felt an urge to smoke, or at a conditioned moment when they would have previously reached for a cigarette, such as after a meal.

"It's like something to do with your hands as well. I feel you miss that holding a cigarette, and that does help quite a bit, and the smoke and the vape up and down does tend to help a bit, yes." [Participant 10, female]

"*The pros [of using an e-cigarette], it's just trying to break the habit of that cigarette from hand to mouth. Yeah with me it's just that habit.*" [Participant 3, Female]

"Sometimes, smoking is a habit, well it is a habit, well not having a cigarette but just a puff on that [e-cigarette] will curb it. Just because you're doing something with your hands." [Participant 4, Female]

Therefore, within the *Automatic motivation* domain of the COM-B framework, this theme highlighted that by replacing the habit of smoking e-cigarettes were an enabler to participation in the smoking cessation intervention.

<u>Reflective motivation</u>

E-cigarette as a back-up in the quit attempt

Most participants regarded the e-cigarette as a useful back-up to the other support they were receiving from the SSS. The devices were not thought to be as dependence-inducing as a cigarette but were a useful alternative to cigarette smoking if and when there was an urge to smoke.

"So, but I'm not on it all the time, like I was with cigarettes. It just, it's slotted in well, but it's not taken over as a replacement of the cigarettes. It's just if you need it." [Participant 4, Female]

"The EC is like a backup. That's how I use them anyway, I don't use them all the time. But on days when you are quitting, and you feel the craving." [Participant 1, Male]

E-cigarettes were reportedly used with lower frequency compared with smoking cigarettes but believed to be a useful method to stabilise the urge to smoke in future at social events or during a stressful situation, once the programme of SSS support had concluded.

"*It'll be there with a plug with a charger I'll have some e-liquid. In case of a social event. In the summertime, you'd be outside. And we would be talking, and I mean, I don't drink. So, but yeah, as a social thing it might be something that might take with me, and it's there if I feel that I need it.* [Participant 5, Male]

"*But having that [e-cigarette] with you, I think you'll be ok. But you don't have to take it like a cigarette you probably only take it three or four times a day. It's just something to steady you up."* [Participant 2, Male]

Within the *Reflective motivation* domain, this theme highlighted that by offering an alternative to smoking at a time when participants were at risk of relapsing, e-cigarettes enabled participation in the smoking cessation intervention.

E-cigarette as a short-term tool to quit smoking

Related to the theme above (describing e-cigarettes as a back-up in the quit attempt), six participants went on to mention that although they felt e-cigarettes were a tool to enable them to quit smoking, they ultimately wanted to cease using the device at some point.

"I'm not putting any [smoking] toxins in my body, which helps. But it [the e-cigarette] is something that in the back of my mind, yeah, I want to get rid of in the long run." [Participant 5, Male]

"I'll probably wean myself off of it, because I'm on six milligrams at the minute. I'll probably take it down to the next level before stopping." [Participant 8, Male]

One participant described his respiratory health concerns as a reason to consider quitting use of the e-cigarette in the near future.

"I think it [the e-cigarette] might be ok. But with my lungs as they are, I should be thinking about quitting altogether." [Participant 2, Male]

Within the *Reflective motivation* domain of the COM-B framework, these mixed responses highlight that by being an attractive option in the short-term, but not the long-term, views towards e-cigarettes can be enabler to intervention participation.

<u>Physical capability</u>

Harshness of puffing

Several participants discussed irritation from using the device, whereby vapour inhalation felt harsh at the back of their throat, and often induced them to cough in response. This reaction was considered to be related to the amount of nicotine in the e-liquid of the device, with higher concentrations conferring greater irritation.

"I was one something like 12mg strength, and if I took a too big a mouthful of that it would make me cough like hell. I did get down to six, and that wasn't too bad, but then six still made me cough like anything trying to get it down." [Participant 2, Male]

"Sometimes there's been a burning in in my mouth at the back of my throat, and I think maybe I've taken too much or there's too much oil in it." [Participant 2, Male]

Within the *Physical capability* domain of the COM-B framework, this theme highlighted that aversiveness experiences with the e-cigarette can be a barrier to participation.

Physical opportunity

Cost saving

A major benefit aside from their effectiveness for smoking cessation was that e-cigarettes were found to be considerably cheaper than cigarettes. A packet of cigarettes was frequently highlighted to cost £10 a pack. E-liquid, in contrast, was known to cost less.

"Yeah they're cheap enough. And if you're packing up smoking you've got to think to yourself that's £10 a packet, and an EC you can buy one for £15 and get two or three oils for £15 as well. So, you're saving ain't you whatever you do if you go out and buy them yourself." [Participant 1, Male]

"*We're putting the money away that we I used to buy cigarettes with. You know we're up to 180 pounds in two weeks. So financially. The cigarettes that we used to buy were twelve pound a packet. So, you keep looking up my little box with my money and thinking what I could buy with that. Yeah what you can do with that money."* [Participant 3, Female]

One participant reflected on being able to put the money saved from not smoking towards purchasing necessities for her family.

"My daughter lost her trainers at school, to cut a long story short, and she comes down the other morning with a picture of a pair of trainers and a £30 gift card. She was like, "mum I need a new pair of trainers, but here's a £30 gift card" kind of thing. So, I ended up putting the rest of the money towards that. The following week I'd done my son a pair of trainers as well. Maybe I would have had to spread the cost over a couple of weeks if I was still buying the cigarettes." [Participant 8, Female]

Within the *Physical opportunity* domain of the COM-B framework, this theme highlighted that compared with cigarettes, the cheaper cost of e-cigarette use was an enabler of participation.

Opportunities to vape

Along with being able to use the e-cigarette in the same social situations and physical locations as a conventional cigarette, it was apparent that six participants had more opportunities to vape in places were smoking was either banned or frowned upon. This included indoors or in the car, with several participants citing the absence of smell and smoke as reasons for usage.

"I've never smoked in the car. I'll have a couple of puffs of that [e-cigarette]. Tony's not gonna know that I've had a couple of puffs. Yeah even indoors, before he comes home from work, I'll have a little puff rather than going out in the garden if it's cold and raining. It's just so easy and it doesn't smell." [Participant 4, Female]

"I can use the e-cigarette indoors. Because it's not actually smoking is it? It's just a vapour in a way." [Participant 2, Male]

This ease of use was highlighted as an advantageous aspect of e-cigarette use, compared with smoking.

"With the e-cigarette instead of having to go and physically have a fag, you could just have a puff on it whenever you fancied needing one, so it gave you the hit whenever you wanted it, really." [Participant 7, Male]

Within the *Physical opportunity* domain of the COM-B framework, this theme highlighted that compared with cigarettes, the greater opportunities to use an e-cigarette enabled participation in the intervention.

Social opportunity

Family support to quit smoking

Family was frequently cited as having a positive influence on the participant's quit attempt with the SSS. This familial support to quit smoking was an important factor driving participant enrolment in the intervention and in continuing to attend sessions.

"My husband has been asking me to give up smoking for years and years and years. But unless you really wanna do it yourself, all the moaning in the world is not gonna make you give up. He would bend over backwards to let us go [to the SSS]" [Participant 4, Female]

Several participants mentioned that younger members of their family had been encouraging of their use of the e-cigarette in their quit attempt due to the lower harm profile compare with smoking cigarettes.

"My daughter, she don't mind me on the e-cigarette. She says I'm much better without smoke. I'm better off with the e-cigarette than I am with a packet of cigarettes." [Participant 2, Male]

Within the *Social opportunity* domain of the COM-B framework, this theme highlighted that family support was an enabler of intervention participation.

6.4 Discussion

6.4.1 Summary

This study reveals that several acceptability factors may have influenced how participants view and use the intervention package. Themes related to acceptability emerged under the domains *Affective attitude*, *Intervention coherence* and *Perceived effectiveness*. However, several aspects of the intervention represented threats to acceptability by participants, specifically related to the *Burden* and *Ethicality* of the intervention. Participants universally voiced positive affect for their stop smoking advisors despite the notable physical burden of attending regular sessions and the effort required to adhere to their regimen of prescription pharmacotherapy (varenicline/Champix), which although conferring unpleasant side-effects was acknowledged to be a highly effective medication. E-cigarettes were generally supported as an aid to quitting smoking, but feelings that the devices perpetuated nicotine addiction discouraged participants from viewing them as a tool beyond the short-term. There were mixed opinions on the appropriateness of e-cigarettes being provided as part of a health service offering. Some voiced support who found e-cigarettes effective, while others believed them inappropriate because e-cigarettes are a widely available consumer product. Nonetheless, the behavioural support, varenicline prescription and e-cigarette treatment package was understood to be a complementary approach by all participants. The Champix pharmacotherapy was perceived to effectively reduce urges to smoke. Overall, participants found the intervention to acceptable despite some notably burdensome characteristics.

Analysis of interviews using the COM-B framework highlighted several potential enablers of the e-cigarette to intervention participation. These enablers fell under the domains of *Reflective motivation*, *Automatic motivation*, *Physical opportunity* and *Social opportunity*. The e-cigarette was believed to help replace the habit of smoking and was a suitable back-up when urges to smoke surfaced. Other factors that encouraged use of the e-cigarette were the notable cost savings accrued compared with smoking cigarettes, and that there was more flexibility in where and when the devices could be used. Most participants highlighted that pressure from members of the family was an important driver of their engagement and attendance with the SSS and offered strong support to persist with the smoking quit attempt. The interviews also highlighted some barriers to participation related to the COM-B domain of *Physical capability*. Some participants experienced harshness when vaping due to naive puff technique and high nicotine concentration e-liquid. In summary, several enablers to participation in the E-ASSIST intervention were related to the perceived effectiveness of the devices for smoking cessation and greater opportunities they presented compared with cigarette smoking.

Summaries of the findings under each theoretical framework are presented in Table 6.8 and Table 6.9 respectively, indicating how each theme reflects enhanced/reduced acceptability under the TFA or is a barrier, enabler (or both) to participation under the COM-B.

6.4.1.1 Acceptability

Table 6.8: Summary of findings on acceptability of the intervention

TFA domain	Theme	Effect on acceptability of intervention*
Affective attitude	Positive affect for advisor	+
Burden	Difficulties with SSS care pathway	-

	Side-effects from Champix	-
Ethicality	E-cigarette replaces one addiction with another	-
	Divergence of opinion on providing an e-cigarette as part of SSS offering	+/-
Intervention coherence	Complementary nature of intervention package	+
Perceived effectiveness	Champix effectively reduces urges to smoke	+

*+ = enhances acceptability; **-** = reduces acceptability

Regarding *Affective attitude* towards the intervention, the fact that all interviewed participants expressed positive affect for their SSS advisor underlines the essential role that specialist practitioners play in engaging with clients and supporting their quit attempt. It was not uncommon in this study sample for participants to be returning to the SSS for a second or third attempt, and they may not have done so without trust in their SSS. The advisor-client relationship was seen as an enabler to participation in the intervention at the SSS and is an important aspect of care given the evidence suggesting that fidelity of delivery of support by advisors is not associated with client attendance.[296] The importance of SSS advisors is underlined further by the Evaluating Long-term Outcomes of NHS Stop Smoking Services (ELONS) study, which highlighted that there is considerable loss to follow-up at SSS, with an estimated one in five clients not returning at the four-week time-point.[56] In terms of *Affective attitude*, positive affect for SSS advisors appeared to improve the acceptability of the E-ASSIST intervention.

Regarding *Burden* of the E-ASSIST intervention, by enrolling at their SSS participants are expected to attend regular (weekly or fortnightly) sessions to receive behavioural counselling and monitoring of progress. This requirement appears to be the most burdensome component of participation in the intervention. With competing priorities, including for instance variable childcare and/or working hours, the physical distance and time available to travel made the intervention less acceptable to some participants. As has been documented previously, for disadvantaged smokers who face more barriers to quitting, the care pathway at SSS is yet another to contend with.[56] However, given that SSS are able to reach disadvantaged smokers is a reminder that, even if access is a challenge, the absence of SSS would be an undoubtedly worse situation.[297] The regimen of pharmacotherapy that participants are required to adhere also lowered acceptability of the intervention. Champix (varenicline) use is association with side-effects including nausea and trouble sleeping.[298] These physical symptoms represent a barrier to prescribed adherence to the medication, and in some instances led to participants skipping a dosage or being changed to a lower prescription. However, in terms of perceived effectiveness, Champix was thought to be the most effective component of the treatment package by physically reducing urges to smoke. The perceived amount of effort to adhere to the 12-week prescription may be of less importance in this context considering that participants are enrolling at the SSS because they have a strong intention to quit smoking and that the behavioural support from advisors can help guide the participant through the course of treatment. Overall, attending sessions and adhering to prescription pharmacotherapy were highlighted to be particularly burdensome, lowering the acceptability of the E-ASSIST intervention at UK SSS.

With respect to *Ethicality* the offer of an e-cigarette as part of the SSS intervention was met with some apprehension related to the device perpetuating perceived nicotine addiction. This finding mirrors research among disadvantaged communities in Northern

England, where e-cigarette use was equated to smoking in terms of nicotine addiction.[299] This evidence for nicotine addiction being a primary concern is substantiated by several E-ASSIST participants indicating that they would like to ultimately stop using the devices at some point, or to cut down their concentration of nicotine. According to PRIME theory[11], addiction is defined as "*a chronic condition involving a repeated powerful motivation to engage in a rewarding behaviour, acquired as a result of engaging in that behaviour, that has significant potential for unintended harm*". As discussed in Chapter 1, while nicotine is a highly dependence-inducing chemical, it is the other chemicals in tobacco smoke and to a lesser extent in e-cigarette vapour that are known to cause harm[4,123] This supports the idea that nicotine dependence is viewed by participants as a moral problem, and this perception may act as a barrier to participation for some individuals. In addition, recent research in both the English SSS and disadvantaged household contexts have also highlighted that attitudes towards e-cigarettes often reflected views on whether switching from smoking to the device represented quitting smoking successfully or perpetuated nicotine addiction.[300,301] Indeed, while there is currently no data on the reasons why a large proportion of eligible recruits appear to turn down the offer of enrolling into E-ASSIST (over 50% from initial estimates), it seems likely that this was a contributing factor. The E-ASSIST sample is self-selected in the sense that even before randomisation, participants had to be willing to use an e-cigarette in their quit attempt.

However, the aforementioned study of English SSS clients did not report the socio-economic chracteristics of its sample, and there do not appear to be any studies specific to the SSS context that have explored client attitudes among a socio-economically diverse sample. This absence of literature limits any potential comparisons of the views of higher

SEP SSS clients with those in this current study. A typology on e-cigarette use drawn from media, academic and online sources reported a majority higher SEP sample and summarised users into those who view ‘vaping as pleasure’, ‘vaping as medical treatment’ and ‘ambivalent about e-cigarette use’.[302] Although vaping for pleasure was highlighted by participants in Chapter 4 of this thesis, it was not mentioned by any in the context of the E-ASSIST supported quit attempt. However, vaping as medical treatment and ambivalence about e-cigarette use are not necessarily discordant from the findings outlined in this current study.

Also related to *Ethicality*, there were divergent opinions among participants about whether e-cigarettes should be offered as part of the programme of support at SSS. Some believed that ex-smokers could put the money saved from no longer purchasing cigarettes towards buying their own e-cigarette. Given that almost all e-cigarettes are a widely available consumer product, there is a strong argument in the context of consistent SSS funding cuts that they may not be provided by SSS. However, partnerships between local vape shops and SSS have the potential to support smokers to quit. Such a scheme is currently being piloted and evaluated by researchers from the University of East Anglia.[303] Overall, in terms of the *Ethicality* of the e-cigarette component concerns were raised about the devices perpetuating nicotine addiction, use of the devices in the long-term, and whether they should be included as part of a publicly funded SSS offering.

In terms of *Intervention coherence,* despite heterogenous views towards the appropriateness of the e-cigarette offering in general participants universally understood the intervention package as involving complementary components. Champix was perceived to be highly effective at reducing urges to smoke (see below *Perceived* *effectiveness)* and was supported by the e-cigarette, which was thought to replace the habit of smoking, and to offer a form of back-up when the urges to smoke surfaced. The behavioural support from SSS advisors was believed to complete the intervention by providing personal support to guide the quit attempt. Although qualitative, these experiences support the hypothesis outlined in section 6.1 regarding the potential augmentation to varenicline that e-cigarettes may have at both the biological and behavioural level. However, only data from the concluded trial will reveal the extent to which this impacted on actual rates of smoking cessation. In sum, participants displayed clear understanding of the intervention and believed the different components to be complementary.

In terms of *Perceived effectiveness,* out of the three components of the E-ASSIST intervention package, Champix was perceived to the most effective for smoking cessation. Participants described losing feelings of craving for a cigarette while on the medication, and would only feel a need to smoke due to habits they had developed.

6.4.1.2 Barriers and enablers

Table 6.9: Summary of findings on barriers and enablers to participation

COM-B domain	Theme	Barrier, Enabler or Mixed*
Automatic motivation	Replacing the habit of smoking	E
Reflective motivation	E-cigarette as a back-up in the quit attempt	E
	E-cigarette is a short-term tool to quit smoking	E/M
Physical capability	Harshness of puffing	B

Physical opportunity	Cost saving	E
	Opportunities to vape	E
Social opportunity	Family support to quit smoking	E

*B = barrier; E = enabler; M = mixed

Regarding barriers and enablers to intervention participation, several characteristics of e-cigarettes were highlighted as enablers of participation in the e-cigarette component of the E-ASSIST intervention. Under the COM-B domain of *Automatic motivation,* e-cigarettes were described as useful for replacing the habit of smoking cigarettes. The devices were described by most participants as effectively substituting cigarette smoking at habitual times of day and circumstances when urges to smoke typically surfaced.

Even where the devices were not viewed as a front-line smoking cessation tool, a theme under the COM-B domain of *Reflective motivation* described how some saw e-cigarettes as a useful back-up in the quit attempt when they were at-risk of relapsing. A further theme highlighted favourable opinions towards e-cigarettes specifically as a short-term tool to quit smoking, with most expressing an interest to stop using their device when they felt comfortable that they would not relapse. This theme showed that beliefs towards the devices can be enabler of participation in the e-cigarette intervention (they are useful to quit smoking with) even though there is hesitance towards longer term usage (they are only considered to be an option in the short term).

Due to their perceived effectiveness for smoking cessation, some participants voiced support for the devices to be made available as part of the standard programme of SSS support. The recognition that e-cigarettes can play a role in smoking cessation suggests that offering them at SSS may encourage increased attendance by lower SEP smokers. However, this has not yet been tested empirically, and is a secondary objective of the overall E-ASSIST RCT. In general, the perception of e-cigarettes for relapse prevention was an enabler to their usage in a quit attempt.

Along with being perceived as a useful tool for participants in their smoking quit attempt, two environmental factors were highlighted which enabled e-cigarette use. Related to the COM-B domain of *Physical opportunity*, the greater opportunities to vape compared with smoking granted users greater flexibility to support their quit attempt. As other research has suggested, urges to smoke can be satisfied conveniently with an e-cigarette.[133] In addition, the greater affordability compared with smoking allowed money to be saved or channelled towards other daily needs. Ethnographic research in Northern England has highlighted that more socio-economically disadvantaged e-cigarette users tend to opt for cheaper devices and e-liquids.[299] Together with results from the current E-ASSIST interviews, the available qualitative data suggest that ensuring e-cigarette use remains cheaper than smoking is key to e-cigarettes being a viable harm reduction alternative across the social gradient.[133] In sum, two enablers of participation in the e-cigarette intervention were the cheaper cost of the devices and the greater opportunities for usage they afforded compared with cigarettes.

An important social factor driving participation in the E-ASSIST intervention was family. Under *Social opportunity,* most participants mentioned that support from members of their family was essential to their engagement and attendance with the SSS, and offered strong support to persist with the smoking quit attempt.

Regarding a potential barrier to use of the e-cigarette, some participants may not have had the *Physical capability* to use their e-cigarette at the start of their quit attempt. Some participants experienced occasional and unpleasant harshness of puffing on their device. This may reflect a naivety to appropriate puff technique. However, the harsh sensory perception was frequently related to the strength of nicotine participants' e-liquid, which supports previous research where higher levels of nicotine increased perceived irritation and bitterness.[304] In sum, lacking the physical skills to use the devices appropriately may be a barrier to the use of the devices within the E-ASSIST intervention.

6.4.2 Common themes to the TFA and COM-B analyses

Several themes in the TFA overlapped with the COM-B framework, and vice-versa. This is not necessarily surprising given that barriers to intervention participation are negatively valanced and therefore lower the acceptability of the intervention. Likewise, enablers to participation likely increase the acceptability of the intervention. Table 6.10 outlines commonality between domains across the two frameworks.

Table 6.10: Commonality between themes in the TFA and COM-B framework

Theoretical framework and domain	**Theme**	**Commonality with framework and domain**	**Comment**
TFA *Affective attitude*	Positive affect for advisor	COM-B *Social opportunity*	Positive feelings for the SSS advisor is a social factor and enabler to intervention participation.
TFA *Burden*	Difficulty with SSS care pathway	COM-B *Physical opportunity*	The burden of attending SSS can be considered a barrier to intervention participation.
TFA *Burden*	Side-effects from Champix	COM-B *Physical opportunity*	The burden of Champix regimen and side-effects can be

			considered a barrier to intervention participation.
TFA *Intervention coherence*	Complementary nature of intervention package	COM-B *Psychological capability*	Intervention coherence in this instance reflects knowledge and capacity that participants have towards intervention participation.
TFA *Ethicality*	E-cigarette replaces one addiction with another	COM-B *Reflective motivation*	The perception of addiction is informed by self-conscious reasoning, and in this instance informs a barrier to participation.
TFA *Ethicality*	Divergence of opinion on providing an e-cigarette as part of SSS offering	COM-B *Reflective motivation*	Reasoning among participations differed according to whether they perceived e-cigarettes to be appropriate at SSS.
COM-B *Automatic motivation*	Replacing the habit of smoking	TFA *Perceived effectiveness*	The acknowledgement that e-cigarettes can replace smoking reflects how participants believe this component of the intervention to be effective at achieving its purpose (smoking cessation)
COM-B *Reflective motivation*	E-cigarette as a back-up in quit attempt	TFA *Perceived effectiveness*	Participants decide that e-cigarettes are a useful back-up to prevent relapse to smoking, highlighting their perception that the devices are an effective component of the intervention.

6.4.3 Limitations

There are several limitations to the findings from this study. Firstly, the small sample of participants were recruited from two out of a possible eight SSS enrolled in the E-ASSIST RCT. It is possible that participants from different local authorities have different attitudes depending on their local context or SSS delivery. It is also likely that recruitment involved in a form of self-selection. SSS clients who selected Champix as a medication option were approached and asked if they were interested in taking part before randomisation. Therefore, individuals who agreed to participate may have already been positively inclined towards the intervention. Moreover, those who are eligible and choose to use Champix as their form of smoking cessation medication may also perceive the intervention differently to those electing to use a different form of pharmacotherapy such as NRT.

As mentioned in section 6.1.2 recruitment for the E-ASSIST RCT was paused due to the COVID-19 epidemic in England. After discussion with participating SSS about any remaining participants who would be available for telephone interviews, this aspect of the process evaluation was suspended having recruited 10 out of a possible 15 participants. However, at the time of study suspension the analysis appeared to have reached data saturation (Appendix 8). Nonetheless I remained attentive to discrepant cases, where participants offered opinions that were considerably different to other responses. It remains possible that further interviews would have provided greater depth to the findings of this study, including further exploration of divergent attitudes between participants. Once E-ASSIST recruitment has resumed, a further interview will be conducted to test whether data were saturated and reported as part of the wider RCT process evaluation.

Due to time resource constraints I was not able to verify the accuracy of the analyses with participants. However, interview participants will be consulted in future as part of the overall process evaluation. In terms of reflexivity, I endeavoured to remain as objective as possible when designing the topic guide and conducting the interviews. However, I cannot discount potentially supportive predispositions that I have towards the effect of e-cigarettes for smoking cessation, which may have influenced my interviewing and interpretation of results. Taken together these limitations suggest that findings from this study should be viewed as exploratory.

Finally, because no recruitment of participants of more advantaged SEP was carried out, it is not possible to make direct comparisons about how the intervention was received across the social gradient. As such I am unable to conclude that the views put forward during are unique to a lower SEP sample.

Notwithstanding these limitations, this study has several strengths. Recent reviews of process evaluations have called for greater consistency in reporting of results and methods used.[305] The use of two theoretical frameworks (TFA and COM-B) are useful to inform intervention theory and highlight potential modifications to the existing intervention. Furthermore, the participatory study has provided an opportunity for more socio-economically disadvantaged recipients of the intervention to feedback on how they experienced it.

6.4.4 Implications for the E-ASSIST RCT

Given the current delays to participant recruitment, the full results from the E-ASSIST RCT will not be available until 2022. In theory, if the intervention is shown to be effective for smoking cessation compared with the usual care control (where participants were not offered an e-cigarette), then this may be partly due to the generally high acceptability and enabling characteristics of the e-cigarette intervention highlighted by this study. Two of the main factors that were found to lower the acceptability of the intervention were related to existing components of usual care (attending SSS sessions and the regimen of pharmacotherapy). Moreover, the finding that participants viewed e-cigarettes as another form of addiction did not seem to deter them from using their device in the short term to quit smoking. Considering that the usual care component of the E-ASSIST intervention is already occurring at SSS around the UK, the addition of an e-cigarette offer is unlikely to be a limiting factor among more disadvantaged recipients. Although exploratory, together the findings from this study suggest that it may be feasible to roll out the intervention to other SSS in the country.

6.4.5 Implications for future implementation of the intervention

Potential modifications of the intervention

This study has highlighted several areas that could be targeted to make the intervention more acceptable to participants, and to reduce perceived barriers to participation. Table 6.10 below outlines potential modifications to future delivery of the E-ASSIST RCT or for similar programmes that are rolled out as a result. Not all themes identified in this study relate to readily modifiable factors and as such are not reflected in Table 6.9. For instance, although the burden of attending regular sessions was highlighted by most participants, suggestions are not made for changes to standard SSS delivery, given the pragmatic nature of the intervention (the e-cigarette offer is fit around the existing programme of support).

Table 6.11: Potential modifications to E-ASSIST intervention to enhance acceptability and facilitators to participation, and alleviate barriers to participation.

Theoretical framework	Theme	Possible modification
TFA	***Ethicality***: *Negative perceptions of nicotine dependence*	Brief training for advisors outlining the principles of harm reduction, comparing harms of tobacco smoke with that of nicotine.
TFA	***Reflective motivation***: *E-cigarette as a short-term tool to quit smoking*	Update educational materials highlighting that e-cigarettes are helpful for

		short-term use to help reduce the immediate withdrawal symptoms following smoking cessation.
COM-B	***Reflective motivation**: E-cigarette as back-up in quit attempt*	Testimonials from previous intervention participants describing how they used their e-cigarette. Illustrates diverse ways to use device in quit attempt.
COM-B	***Physical capability**: Harshness of puffing*	Direction to online content from online vape forums about puff technique when participants first start using their e-cigarette.
COM-B	***Physical opportunity**: Cost*	Partnerships/voucher schemes with local vape shops to incentivise use of e-cigarette in quit attempt and lessen cost of e-liquid.

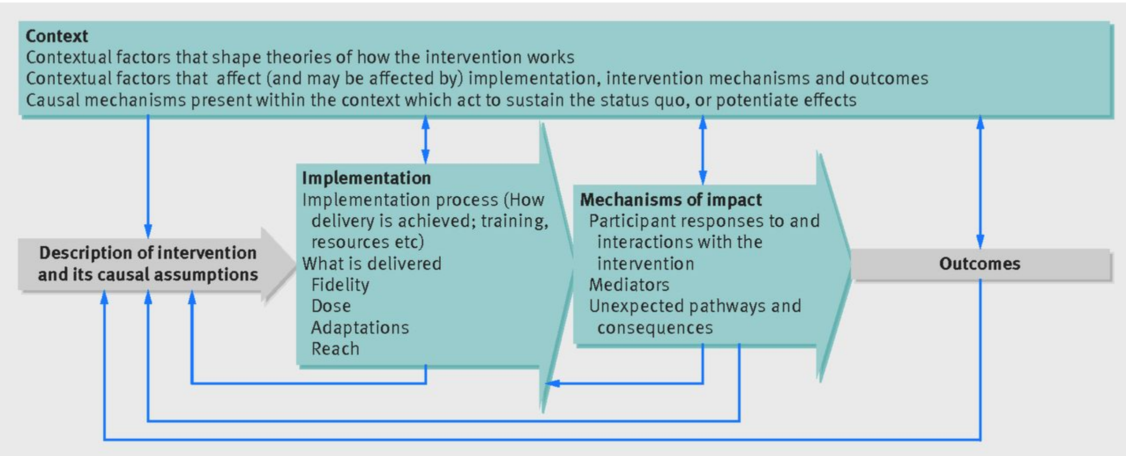
6.4.6 Future research

Future work: E-ASSIST process evaluation

RCTs are an important method to assess the effectiveness of interventions in public health. However, unless an RCT is taking place in a tightly managed clinical setting, which is more typical of drug and vaccine trials, the behaviour of participants in the real world across different arms of the trial are less easy to control and can have a meaningful influence on outcomes. Without understanding important contextual factors influencing adherence to a given intervention, or contamination (use of the treatment/intervention by those who were not allocated to receive it), results of an RCT can be misleading and unable to improve or replicate the delivery of the intervention and outcomes in other settings.[292] This contextual understanding is even more relevant for complex interventions (such as E-ASSIST), which involve multiple interacting components and can require several behaviours to be delivered by providers or enacted by participants outside of the clinical setting.

Process evaluations conducted alongside RCTs are a means to examine the processes through which an intervention generates outcomes. They assess whether a new intervention can be implemented in multiple and/or resource scarce settings, if there are emergent problems in delivery that can be alleviated in future iterations, and how and why people choose to participate in the intervention.[306] According to the UK Medical Research Council (MRC) guidance, a process evaluation can highlight what and how an intervention is implemented, how the intervention produces change (mechanisms of impact) and how the context in which an intervention takes place affect its implementation and outcomes (Figure 6.2).

Figure 6.2: Key functions of a process evaluation (MRC)[292]



In recent years, recognition and support for process evaluations conducted alongside RCTs has grown, following 2008 MRC guidance that they should be used to “assess fidelity and quality of implementation, clarify causal mechanisms and identify contextual factors associated with variation in outcomes”.[306]

This study has presented data from the participant-focussed component of a wider process evaluation of the E-ASSIST RCT. For a fuller understanding of the intervention, future work will include an examination of fidelity of delivery and enactment. Fidelity, a multidimensional construct, assesses whether an intervention was delivered as intended.[292] Fidelity in this context is important to measure because it can influence the reliability and validity of any behavioural intervention including those in the context of smoking cessation.[307] Fidelity can be applied at both the provider and recipient level. At the provider level, fidelity of delivery of support can be assessed by measuring the extent to which providers conducted the intervention programme as intended. Research has shown evidence of variation in how stop smoking services and stop smoking practitioners deliver behaviour support sessions both in terms of the specific BCTs that are delivered, and how well these BCTs are delivered.[78] Further studies in this area have indicated that there is lack of adherence to stop smoking service protocols and evidence-based guidelines.[72] At the trial participant level, fidelity of enactment is defined as how participants received an intervention and whether they adhered to a programme of support that was prescribed to them. In the context of this RCT the important fidelity process factors that might influence outcomes include participant pharmacotherapy adherence[308] and e-cigarette usage. Although originally planned to be included, due to delays in data collection and the aforementioned suspension of trial recruitment due to social distancing measures in the UK, fidelity of delivery and enactment are not being considered in this thesis. However, these will be reported along with the RCT findings as and when they are available.

In summary, the future process evaluation of the E-ASSIST RCT will integrate the findings from this study on acceptability and barriers and enablers to participation, and also assess (across both trial arms) 1) fidelity of delivery of support by characterising the BCTs delivered and examining whether stop smoking practitioners delivered the support as intended according to the SSS manual and 2) fidelity of enactment by measuring adherence to prescribed medication and e-cigarette usage by all participants.

6.5 Conclusions

This qualitative study found that the E-ASSIST intervention was generally acceptable among a lower SEP sample. Participants highlighted positive affect towards their SSS advisor, which likely encouraged participants to overcome the burden of having to travel to attend regular sessions at the SSS and adhere to prescription medication. E-cigarettes were generally thought to be an effective tool for smoking cessation, but negative perception towards nicotine use discouraged device usage in the long term and influenced mixed opinions on whether they should be provided at SSS. Participants understood the intervention package to be complementary, with Champix primarily reducing urges to smoke and the e-cigarette replacing the habitual nature of smoking. In terms of barriers and enablers to participation, e-cigarettes were thought to replace the habit of smoking and offer a back-up to the rest of the intervention package when participants were at risk of relapse. E-cigarettes were found to be cheaper than smoking and more flexible to use. Familial support was a key driver participants' attempt to quit attempt. The perceived harshness of vaping may be a barrier to device usage at the early stages of the quit attempt. The TFA and COM-B frameworks permitted a theoretical analysis of the acceptability of the E-ASSIST intervention among participants and the potential barriers and enablers to participation. Findings from this study can be used to help guide future intervention implementation of complex individual-level smoking cessation interventions of this nature, where many recipients are of lower-SEP.

Chapter 7

General Discussion

This final chapter will summarise the main findings from the thesis, reflect upon its strengths and limitations, outline areas for future research, and discuss practical implications of the findings in a broader context.

7.1 Summary of findings

The aim of this thesis was to use mixed-methods to assess the potential impact of e-cigarettes and individual-level interventions on socio-economic inequalities in smoking cessation. The thesis addressed three main objectives:

1) To systematically review the literature and assess the effectiveness of individual-level behavioural interventions tailored for disadvantaged SEP.
2) To model population-level trends in e-cigarette usage by SEP using representative data in England.
3) To qualitatively explore among lower SEP participants i) the motivations and patterns of e-cigarette usage during an unsupported quit attempt and ii) the acceptability and barriers and enablers to participation of an individual-level smoking cessation intervention involving the offer of an e-cigarette.

Study 1 was situated under the first objective, studies 2 and 3 under the second objective, and studies 4 and five under the third objective.

Regarding the first objective, using meta-regression analysis study 1 assessed whether the effectiveness of individual-level behavioural smoking cessation interventions for disadvantaged groups was moderated by tailoring for SEP. 42 randomised controlled trials (RCTs) of SEP-tailored and non-SEP-tailored individual-level behavioural interventions for smoking cessation were included. The results of study 1 showed that all interventions (both SEP-tailored and non-SEP-tailored) were found to be effective for smoking cessation compared with control or usual care, but that SEP-tailored interventions did not moderate effectiveness compared with non-SEP-tailored interventions in disadvantaged groups. This may be because lower SEP individuals face more facilitators to smoking uptake and more barriers to quitting (section 1.3), which may outweigh the benefits of current forms of tailoring of interventions at the individual level.

Further sub-group meta-analyses indicated with low certainty that the effects of non-SEP-tailored interventions on smoking cessation were similar in both low-SEP and high-SEP participants. Study 1 highlighted that strengthening SEP-tailored intervention design and delivery is likely to be necessary if they are to improve upon existing non-SEP-tailored interventions for smoking cessation in disadvantaged groups.

Under objective two, study 2 examined whether there were any associations between SEP and e-cigarette use from 2014 to 2017 among all adults, past-year smokers, smokers during a quit attempt and long-term (>1-year) ex-smokers. Cross-sectional data from 81,067 respondents in the Smoking Toolkit Study (STS) were used, and the analyses were stratified by year to assess the changes in these associations over time. E-cigarette use was greater among socio-economically disadvantaged adults compared with more advantaged adults. A socio-economic gradient in e-cigarette use was also evident among past-year smokers but ran in the opposite direction with e-cigarette use more prevalent among more advantaged respondents. This gradient within past-year smokers attenuated over time whereby use appeared similar across the socio-economic spectrum by 2017. There were no significant differences in e-cigarette use during a quit attempt by SEP throughout the entire time period. The use of e-cigarettes by long-term ex-smokers increased over time among all respondents but was consistently more prevalent in ex-smokers from lower SEP groups. These results indicated the importance of continued surveillance of the socio-economic patterning among long-term ex-smokers as a specific sub-group, and highlighted a need to interrogate the data further by subgrouping individuals according to whether they started using an e-cigarette only after they had quit smoking or who used the devices during a quit attempt and continue to use them afterwards.

Also under objective two, study 3 assessed trends in current e-cigarette use by SEP from 2014 to 2019 among i) all long-term ex-smokers (quit smoking for >1 year) and, to capture post-cessation uptake among ii) past-year ex-smokers who did not use an e-cigarette in their most recent quit attempt (representing recent uptake), and iii) long-term ex-smokers who quit smoking before e-cigarettes became popular in 2011 (representing late uptake). In this cross-sectional study of 34,442 former smokers from the STS, e-cigarette use increased from 2014 and 2019 among all long-term ex-smokers but was consistently more prevalent among those of lower SEP. Regarding post-cessation uptake of e-cigarettes, among those who quit smoking in the past year but who did not use an e-cigarette to do so, there was no clear trend over time or any difference according to SEP. Among those who quit smoking before 2011, there was small but significant increase in e-cigarette use between 2014 and 2019 but no evidence for an association between SEP and e-cigarette use. The findings from this study suggested that in long-term ex-smokers, e-cigarette use is more common among those who are more disadvantaged and likely reflects continued use of e-cigarettes as a long-term cessation aid. Equity positive or negative impacts of this usage will likely depend upon whether e-cigarettes confer a public health benefit of protection against long-term relapse to smoking.

Regarding the third objective of this theses, study 4 explored patterns of e-cigarette usage and attitudes towards e-cigarettes during an attempt to quit smoking among a group of lower SEP sample of smokers. Comparisons between self-reported ecological momentary assessment (EMA) and objectively recorded data on e-cigarette usage found poor correspondence between measures of both the number of sessions with the device in a day, and the number of puffs taken in the most recent session. Qualitative analysis showed all participants intended on using an e-cigarette to support their current or future quit attempt. Participants were trying to quit smoking with an e-cigarette to improve health and save money and, in some instances, due to a feeling of responsibility to quit for their family. Some saw e-cigarettes as both a smoking cessation tool and a pleasurable activity, while others perceived the devices to be a tool and nothing more. Several participants described poor mental health being a limiting factor disrupting their ability to successfully quit smoking. This study highlighted the potential that e-cigarettes have towards supporting more heavily dependent lower SEP smokers in quitting smoking.

Informed by the theoretical framework for acceptability (TFA) and the COM-B model, study 5 (also under objective three) aimed to explore the acceptability and barriers and enablers of offering an e-cigarette in addition to pharmacotherapy and behavioural support at stop smoking services (SSS) in England (the E-ASSIST trial) among more socio-economically disadvantaged participants. This individual-level intervention was generally found to be acceptable. Participants highlighted positive affect towards their SSS advisor, which likely encouraged participants to overcome the burden of attending regular sessions at the SSS and adhere to pharmacotherapy. E-cigarettes were generally thought to be helpful for smoking cessation, but negative perception towards nicotine use discouraged device usage in the long term and influenced mixed opinions on whether they should be provided at SSS. All participants believed the intervention package to be complementary. In terms of enablers to participation, participants believed that e-cigarettes could replace the habit of smoking and offer a back-up to the rest of the intervention package when they were at risk of relapse. The devices were found to be cheaper than smoking and more flexible to use. Familial support was a key driver behind quit attempts. In terms of barriers to participation, the perceived harshness of vaping may disrupt device usage at the early stages of the quit attempt. This study highlighted good acceptability of the E-ASSIST intervention among lower SEP participants. To improve acceptability, future intervention development could involve clearer information on the principles of harm reduction and nicotine dependence, along with testimonies from previous participations. To enhance the effect of the comparatively cheaper cost of e-cigarettes as an enabler to participation, partnerships and voucher schemes with local vape shops may present opportunities for even greater cost-savings for lower SEP participants.

This thesis has reported on i) a systematic review of effectiveness of individual-level interventions tailored for disadvantaged SEP, ii) the population-level trends in e-cigarette usage by SEP in England and iii) among lower SEP participants, the motivations and patterns of e-cigarette usage during an unsupported quit attempt, and the acceptability of an individual-level supported quit attempt involving the offer of an e-cigarette. Based on these findings, relevant implications for inequalities in smoking cessation are presented.

7.2 Implications for inequalities in smoking cessation

The finding in study 1 that there are currently no large moderating effects of tailoring interventions for disadvantaged smokers compared with not tailoring suggests that current forms of SEP-tailoring may not do enough to overcome existing socio-economic determinants of smoking. Existing individual-level approaches that take either an SEP-tailored or non-SEP-tailored approach could be improved through integration with approaches at the community and population level that take a broader view of the structural inequalities underlying smoking (what this means in practice is discussed in the reflection section 7.5 below). Moreover, study 1 highlighted that certain forms of behavioural support appear to be more effective than others, namely those that include some form of financial incentive or pharmacotherapy, and should therefore continue to be promoted in smoking cessation programmes. The findings from study 1 also have implications for the existing delivery of non-SEP-tailored interventions. It is important to reaffirm the distinction here between tailored and targeted interventions for disadvantaged smokers. SEP-tailored interventions involve some specific design or adaptation for lower SEP smokers. In contrast, targeted interventions may be delivered in a disadvantaged context, but do not involve any specific design for lower SEP smokers and as such do not constitute tailoring. A recent review by Smith et al highlighted that targeted SSS delivery in Scotland saw the smoking cessation rate of disadvantaged smokers exceed that of more affluent groups.[115] Most existing SSS interventions in the UK are non-SEP-tailored. Supported by the findings from study 1 of this current thesis (that non-SEP-tailored interventions appear similarly effective in both low- and high-SEP groups), the evidence from the Smith et al study suggests that when effectively targeted at disadvantaged smokers, non-SEP-tailored interventions can have an equity-positive impact on smoking cessation while also being potentially less resource intensive.

Two studies in this thesis report on the trends in e-cigarette use by SEP. The findings from study 2, examining use among all adults, past-year smokers, during a quit attempt, and long-term (>1 year) ex-smokers raised three important implications. First, the difference in e-cigarette usage among smokers across the social gradient appeared to decrease between 2014 and 2017 such that the apparent greater usage among higher SEP groups at the start of the time period was no longer evident in 2017. This broadly follows the theory of diffusion of innovations where, among smokers, early adopters of e-cigarettes were generally of higher SEP before greater adoption of the devices occurred among lower SEP groups.[165] If overall adoption of e-cigarettes increases among lower SEP groups in future, then this could potentially displace some cigarette smoking and lead to greater reductions in cigarette consumption among dual users (people who are concurrent users of e-cigarettes and cigarettes) as a result. Second, the absence of socio-economic differences in e-cigarette use during a quit attempt between 2014-2017, along with evidence that the devices appear equally effective across socio-economic groups[250], indicated that this is unlikely to have a material impact on inequalities in smoking cessation. Had differences in use been found then this would have had important implications on inequalities given the growing evidence for their effectiveness as a smoking cessation tool.[136,138,140,309] Third, the greater and increasing trend in e-cigarette use among lower compared with higher SEP long-term ex-smokers highlighted that further work was needed to understand whether the trend reflected continued e-cigarette use following a successful quit attempt, or was partly due to initiation of use only following smoking cessation. Following directly on from this finding and with data from 2014-2019, study 3 indicated that the among lower-SEP long-term ex-smokers the use of e-cigarettes was most likely due to continued use of the devices as a long-term smoking cessation aid. The impact that this pattern may have on health inequalities hinges upon whether e-cigarettes are protective against users relapsing to cigarette smoking.[260] The observation that lower SEP smokers are more likely to continue to use e-cigarettes in the longer term could be beneficial if they confer protection. Conversely, a lack of protection has important implications given that the resumption of smoking makes the lower risk profile of e-cigarette use less beneficial in the long run. Understanding how e-cigarettes affects long-term relapse to smoking is an important research priority. However, if future research confirms that there is some increased likelihood for relapse among long-term e-cigarette users, it is important to assess this in the context of the benefits resulting from e-cigarettes increasing the rate of smoking cessation at the population level. For instance, if e-cigarette use leads to smoking cessation among those who would not have quit otherwise, then this benefit may hold even when a higher proportion of these individuals relapse to smoking. However, in terms of inequalities these potential benefits for population health may be equity negative if most relapse occurs among lower compared with higher SEP individuals.

This thesis reports on the patterns of e-cigarette usage and motivations for use in a quit attempt among lower SEP smokers. Although not conclusive, the findings from study 4 highlight the challenge inherent in collecting accurate self-reported frequency of e-cigarette usage data, showing poor correspondence with the objective measure of usage across the study sample (where data was available). More objective and visual measures of recall, such as volume of e-liquid consumed, are recommended for future research in addition to device frequency and puff data. From the perspective of lower SEP smokers, the lower cost and perceived health benefits of vaping compared with smoking, along with the pleasure and satisfaction that some derive from it make e-cigarettes an attractive alternative to cigarettes. Despite a perception that e-cigarettes were useful, poor mental health was raised by participants as a barrier to successful smoking cessation. Individuals who experience the intersection of socio-economic disadvantage and poor mental health are less likely to quit nicotine use altogether due to higher levels of dependency and because it may offer some self-medicating properties.[310] If such individuals are accessing mental health support services, then there is an opportunity to integrate the offer of e-cigarettes within clinical practice (as has been demonstrated with a specialist smoking cessation package[311]) and reduce the currently disproportionate burden of disease caused by tobacco smoking in this population.

The findings from the qualitative study exploring acceptability of and barriers and enablers to participation in the E-ASSIST intervention suggested that the approach is broadly acceptable to lower SEP clients attending SSS. The outcomes of the E-ASSIST RCT will not be reported for some time, but should it prove to be an effective intervention for smoking cessation then the findings from interviews with participants suggested that it will be well received by clients at other SSS in the UK. The study also highlighted potential ways through which intervention acceptability could be improved, such as training for advisors around harm reduction and nicotine dependence and provision of clearer information about e-cigarettes as a short-term tool for smoking cessation. Given the pause in recruitment due to the COVID-19 epidemic in England, findings from this study may be well-timed in that along with informing design and delivery of similar interventions in future, they can also help adapt the ongoing delivery of the E-ASSIST intervention.

Lower SEP participants in both study 4 and study 5 highlighted their sensitivity to the price of e-cigarettes and e-liquid compared with smoking cigarettes, citing the cheaper cost of the former as an important enabler of use. This has important implications for future product taxation in the UK. Should higher taxes be levied on e-cigarettes (as has been proposed or enacted by state governments in the US), the increased price borne upon consumers may dissuade many lower income smokers from switching and either encourage relapse among the ex-smoker population described in studies 2 and 3 or drive them into an unregulated black-market lacking in standards for device and e-liquid safety.[157] The benefit of e-cigarettes for disadvantaged smokers, and therefore for reducing smoking related health inequalities, is largely dependent upon them remaining a cheaper alternative to cigarettes.

7.3 Strengths

This programme of research used mixed methods and sources of data, namely i) meta-analysis of results from multiple RCTs (study 1), ii) regression analyses of representative data from large population samples (studies 2 and 3), and iii) qualitative analyses of interview data from a purposive sample of lower SEP participants (studies 4 and 5). This combination of RCT-, population- and individual-level data facilitated a more holistic understanding of inequalities in smoking cessation than would have been possible with one source of data or method.

The set-up and launch of the E-ASSIST RCT and parallel process evaluation (within which study 5 was nested) has forged good working relationships with public health practitioners outside of academia working in the field of smoking cessation. Along with creating opportunities for future collaboration, results from these studies can directly inform future practice on the provision or offer of e-cigarettes in the clinical setting.

There remains a need for continued work to understand ways to help more socio-economically disadvantaged smokers quit. Smoking rates in the UK continue to differ according to SEP, with the most recent NHS report highlighting that 29% of those with no formal qualifications currently smoke compared with 9% of those with a university degree or equivalent.[26] By monitoring and assessing current interventions and tools for smoking cessation according to SEP, this thesis has contributed new evidence to aid in the decision making for public health policy and practice.

Finally, this thesis closely adhered to the principles of ‘Open Science’.[312] For studies 1 to 3, this included publicly pre-registering the methods and planned analyses with the open science framework, making all data and statistical code freely available and publishing the results in open access journals. Together these actions should promote greater transparency and improve the robustness of research presented in this thesis.[313] The only exceptions to pre-registration were qualitative studies 4 and 5. For these studies I deemed the pre-registration of study protocols was less relevant due to the exploratory nature of the research, and considering the small and distinctive sample populations involved.

7.4 Limitations

This thesis has examined two different forms of intervention, behavioural and pharmacological, for smoking cessation to different degrees. Despite consisting of a heterogenous mix of delivery methods (section 1.5.2) individual-level behavioural interventions were examined broadly under the same category in study 1. This is in contrast to e-cigarettes, which were assessed as a smoking cessation aid in greater detail. Focussing the thesis on either of individual-level interventions or e-cigarettes specifically may have provided greater depth of understanding of the respective approach. However, it could be argued that a broader understanding has been generated from their integration.

Studies 2 and 3 provided useful updates on the trends in e-cigarette use across the socio-economic spectrum in England. However, as is common for population-level surveys evaluating smoking behaviour, the results are limited by the use of cross-sectional survey data. Important questions that were raised relating to the investigation of relapse to smoking among e-cigarette users could not be explored further as they would be with a longitudinal dataset.

Socio-economic disadvantage is a multi-dimensional construct. In this thesis social grade based on occupation was operationalised as the primary indicator of SEP. This has some limitations. First, categorisation of people who are not currently working into the lowest grade E does not always reflect equivalent SEP. For example, individuals who are now retired, but during their career accrued significant wealth, are placed in the same group as those who are unemployed and on state benefits. The same applies to students in higher education, who may not be currently employed but have good future employment and earnings prospects. Second, some groups are not easy to define. It is unclear whether a self-employed manual worker who has responsibility over others should be classified as a skilled manual worker or a manager.

7.5 Reflections: a systems perspective

This thesis has focussed on individual-level interventions and e-cigarettes, and their impact on inequalities in smoking cessation. Some debate in public health has argued around the relative benefits of interventions that target unhealthy behaviours at the individual level versus 'upstream' structural changes that act through the social and physical environment to influence behaviour at the population level.[174] Evidence from this thesis and wider research shows that individual-level interventions and e-cigarettes are useful tools to help people quit smoking and may have benefits among lower SEP smokers. However, as tools they cannot address the underlying causes of smoking inequalities in the UK and elsewhere. As outlined in section 1.3, some key determinants that make smoking cessation less likely include greater nicotine dependence, lower motivation to quit, less social support, greater life stress, lower self-efficacy, greater tobacco industry targeting and poorer treatment adherence. Moreover, disadvantaged individuals who successfully quit smoking often face more environmental facilitators to smoking relapse such as greater exposure to smoking by friends and family, easier access to cigarettes and more social problems. These underlying factors are themselves largely driven by the conditions that people grow-up, live and work in.[49] On a fundamental level, if the prevalence of smoking is lower among more socio-economically advantaged groups, then it is likely that some form of redistribution of wealth and opportunity in society (through measures such as more progressive wealth taxation and improvements in education), alongside continued implementation of evidence-based tobacco control measures, would lead to overall reductions and a more equal distribution of smoking and other socio-economically patterned harmful behaviours. In the absence of this systemic change, important population-level policies such as those that influence the price of cigarettes can reach more smokers than individual-level interventions and have been shown to be effective for smoking cessation.[314] However, it does not follow that individual-level interventions that target specific behaviours do not have value. As others have argued, to develop a true understanding of the complex system influencing smoking behaviour one must consider the problem on multiple levels, where individual agents interact and feedback in dynamic ways with each other and the overall system.[58] For instance, some more disadvantaged and dependent smokers may adapt their smoking behaviour to avoid the effects of effective population-level interventions such as increases in the tax on cigarettes.[51]

Similarly, in the context of smoke-free legislation, e-cigarettes may be an attractive alternative to smokers. The benefits on smoking cessation seen at the population-level from e-cigarette use may to some extent be a function of the flexibility as to where people can vape. Restricting e-cigarette usage in a similar way to cigarettes may undermine this. Acknowledging individual smoker characteristics and agency allows researchers and policymakers to develop more nuanced and dynamic policies and packages of interventions (i.e. at both the individual- and population-level) to promote smoking cessation and ensure that certain groups are not left behind. For example, improving access to SSS in disadvantaged communities allows smokers who are unable to quit, and are penalised for continuing to smoke through tax increases, to receive behavioural support, pharmacotherapy and alternatives to smoking.

E-cigarettes are an example of an intervention that has individual-level properties and emergent population-level effects. The devices can help more dependent smokers quit who would not have otherwise by offering an effective, cheaper, and for many an enjoyable replacement for tobacco cigarettes but without much of the harm associated with smoking. The growth in the use of e-cigarettes by individuals who used to smoke has fostered a community of vapers that now encourages and empowers smokers to stop. Whether the devices can reduce existing inequalities in smoking by encouraging a greater proportion of disadvantaged smokers to switch remains to be seen, but by applying a systems lens to this problem, it is possible to elucidate intended and unintended consequences of both population- and individual-level interventions on inequalities.

7.6 Future research

Future research on SEP-tailored interventions should use theory informed frameworks of behaviour change such as the behaviour change technique (BCT) taxonomy[315] to identify i) the intervention components used, and through meta-regression techniques ii) assess the relative effectiveness of each intervention component for smoking cessation in disadvantaged groups.[73] Results from the univariate meta-regression analyses in study 2 of this thesis (see section 2.5) suggested that interventions involving financial incentives (which would be coded into the BCTs of 'incentive' or 'material reward' under the 'reinforcement' domain of the BCT taxonomy) may moderate effectiveness for smoking cessation compared with interventions involving other forms of behavioural support. Taking a systematic and iterative approach to future SEP-tailored intervention design that identifies and integrates BCTs deemed to be effective could improve the outcomes of future smoking cessation programmes among disadvantaged smokers.

Following on from this and the reflections posited above (see section 7.5), future research on novel SEP-tailored interventions for smoking cessation might benefit from applying systems science methods. Microsimulation, as one such method, can help identify how unequal exposures and risk factors lead to differential risk among individuals within a population.[316] For instance, having identified certain intervention components that are associated with improved outcomes among lower SEP smokers receiving individual-level support, the effectiveness of these components could be tested by including them as an add-on to an existing SSS intervention among lower SEP smokers identified as at higher risk of relapse (due to multiple likely correlated risk-factors such as greater peer/family smoking, greater dependency, less education and lower income[46]). Instead of conducting a potentially costly RCT in a resource poor setting, the impact and cost-effectiveness of the intervention could be assessed by modelling the predicted outcomes in a theoretical representative sample population that received the intervention, and comparing this with the outcomes in the same population if they didn't receive the intervention. A microsimulation model in this context would be preferable over a traditional cohort model because it does not simply take into account the average risk factors for relapse in each subpopulation, but rather considers the benefits it has for the higher-risk subgroup of lower SEP smokers. Each individual in the model would be provided with a specific value for each risk factor (i.e. education, income, exposure to other smokers, nicotine dependence etc) by sampling from correlated probability distributions of these factors, thus capturing the skewed nature of the risk distribution. This study would require the creation of an index to estimate the risk of relapse based on underlying risk factors related to SEP (similar to the Framingham 'risk equations' that estimate the risk of myocardial infarction of stroke over a decade given a set of risk factors such as sex, age, smoking history, blood pressure[317]), and would also require data on how different intervention components influenced outcomes across the social gradient. Assuming that this was possible, by applying the risk index to each individual in the model with and without the SEP-tailored intervention a more accurate understanding of the potential benefits (driven by the lower-SEP/higher-risk individuals who benefit the most) could be captured. Furthermore, such a model could be used to identify how changes to the inclusion criteria for the intervention (i.e. enrolling those with slightly different levels of the SEP/relapse risk index) might impact on the outcomes of the intervention.

The Smoking Toolkit Study is soon to be expanded to collect representative data from other devolved nations in the UK. This will allow analysis of socio-demographic patterns and trends in e-cigarette use in different socio-economic groups to continue at the population level across England, Scotland and Wales. Following on from the findings in study 4 of this thesis, further research is necessary to interrogate whether e-cigarette use among long-term ex-smokers is associated with relapse to tobacco smoking. This will require the use of longitudinal data that track a cohort of ex-smokers over time and assess whether e-cigarette use predicts relapse among those who have been abstinent from smoking for >1 year. This analysis will need to control for past cigarette dependence using reliable measures such as the heaviness of smoking index.[318] Without this information, findings showing a positive association between e-cigarette use and relapse to smoking[259,260] (see Chapter 4 section 4.3) could be confounded due to e-cigarette using ex-smokers being more nicotine dependent than non-users. In this context e-cigarette use may reflect a coping strategy among more dependent users rather than the devices increasing the likelihood of relapse.

As a result of the distancing measures mandated during the COVID-19 epidemic, SSS delivery in England has shifted to mostly involve telephone and virtual consultations.[319] These changes in service delivery may have impacted the effectiveness of smoking cessation interventions, both overall but also among specific socio-economic subgroups. In theory the move from in-person to telephone/virtual behavioural support and digital approval of prescription pharmacotherapies could potentially make it easier for lower SEP clients (such as those in study 6), who struggle to attend the in-person clinics. Conversely, the benefits of in-person clinics such as the rapport and caring relationship that practitioners build with their clients (also highlighted in study 6) may be lost, which could negatively affect smoking cessation. If weekly or monthly data were available from NHS SSS statistics, time-series analysis methods could be used to assess whether there has been a step change in smoking cessation at SSS since the mode of delivery changed. Further use of qualitative methods could also be used to understand how the changes were affecting more disadvantaged clients enrolled at SSS.

7.7 Final remarks

Using mixed methods this thesis reports on the potential impact that e-cigarettes and individual-level interventions have on existing inequalities in smoking cessation. SEP-tailored behavioural interventions were found to be no more effective than non-SEP-tailored interventions for smoking cessation among lower SEP smokers. Population-level modelling showed that between 2014-2019 e-cigarette use increased overall among long-term ex-smokers and was highest among those of lower SEP, highlighting a need for evidence on whether the devices protect against relapse. Interviews highlighted that motivations of lower SEP smokers to use an e-cigarette in their quit attempt relate to improved health, to save money, for family, and because they enjoyed using one. Results from interviews with lower SEP individuals attending their local stop smoking service suggested that a non-SEP-tailored intervention involving the offer of an e-cigarette alongside behavioural support and pharmacotherapy was broadly acceptable. The main enablers to participation fell within the opportunity and motivation domains of the COM-B framework, while the main barrier was categorised under the capability domain.

This thesis has highlighted that although effectively helping disadvantaged smokers quit, SEP-tailored and non-SEP-tailored interventions do not currently appear to be equity positive. To reduce inequalities in long-term smoking cessation, individual-level interventions need to demonstrate a greater effect among lower compared with higher

SEP groups after at least six months following a quit attempt. SSS have experienced cuts in funding in recent years, with likely negative implications on access by more dependent and disadvantaged smokers. In this context, many of these individuals may see e-cigarettes as an acceptable and attractive alternative or adjuvant to individual-level support. E-cigarette use has become more prevalent among lower SEP smokers and ex-smokers, and the devices appear to be equally effective for smoking cessation across all socio-economic groups. If the observed longer-term use of e-cigarettes among disadvantaged compared with more affluent ex-smokers is shown to be a function of dependency, then even if some individuals relapse the devices may have provided a route out of smoking for others that would have otherwise not been possible. Were this true, harm reduction conferred through the use of e-cigarettes may contribute towards reducing smoking-related health inequalities.

These findings can inform the development and evaluation of future individual-level smoking cessation interventions in socio-economically disadvantaged groups and guide future research into more focussed equity-related outcomes of e-cigarette use for smoking cessation.

Bibliography

1. World Health Organisation. *Growing Tobacco*.; 2016. https://www.who.int/tobacco/en/atlas16.pdf. Accessed January 8, 2020.
2. Euromonitor International. *Cigarettes*.; 2018. https://www.euromonitor.com/cigarettes. Accessed January 6, 2020.
3. Borgerding M, Klus H. Analysis of complex mixtures – Cigarette smoke. *Exp Toxicol Pathol*. 2005;57:43-73. doi:10.1016/J.ETP.2005.05.010

4. Benowitz NL. Nicotine Addiction. Schwartz RS, ed. *N Engl J Med*. 2010;362(24):2295-2303. doi:10.1056/NEJMra0809890
5. Benowitz NL, Burbank AD. Cardiovascular toxicity of nicotine: Implications for electronic cigarette use. *Trends Cardiovasc Med*. 2016;26(6):515-523. doi:10.1016/j.tcm.2016.03.001
6. Nestler EJ. Is there a common molecular pathway for addiction? *Nat Neurosci*. 2005;8(11):1445-1449. doi:10.1038/nn1578
7. Balfour DJK. The neuronal pathways mediating the behavioral and addictive properties of nicotine. *Handb Exp Pharmacol*. 2009;192:209-233. doi:10.1007/978-3-540-69248-5_8
8. West R, Shiffman S. *Fast Facts: Smoking Cessation*. Karger Medical and Scientific Publishers; 2016.
9. Ashok AH, Mizuno Y, Howes OD. Tobacco smoking and dopaminergic function in humans: a meta-analysis of molecular imaging studies. *Psychopharmacology (Berl)*. 2019;236(4):1119-1129. doi:10.1007/s00213-019-05196-1
10. Zhou FM, Liang Y, Dani JA. Endogenous nicotinic cholinergic activity regulates dopamine release in the striatum. *Nat Neurosci*. 2001;4(12):1224-1229. doi:10.1038/nn769
11. West R, Brown J. *Theory of Addiction*. John Wiley & Sons; 2013.
12. WHO. *Tobacco: Key Facts*.; 2019. http://www.who.int/news-room/fact-sheets/detail/tobacco. Accessed November 2, 2018.
13. Reitsma MB, Fullman N, Ng M, et al. Smoking prevalence and attributable disease burden in 195 countries and territories, 1990–2015: a systematic analysis from the Global Burden of Disease Study 2015. *Lancet*. 2017;389(10082):1885-1906. doi:10.1016/S0140-6736(17)30819-X
14. The Tobacco Atlas. *Consumption*.; 2018. https://tobaccoatlas.org/topic/consumption/. Accessed November 2, 2018.
15. Wipfli H, Samet JM. One Hundred Years in the Making: The Global Tobacco Epidemic. *Annu Rev Public Health*. 2016;37(1):149-166. doi:10.1146/annurev-publhealth-032315-021850
16. WHO. *The WHO Framework Convention on Tobacco Control: An Overview*.; 2015. http://www.who.int/fctc/about/WHO_FCTC_summary_January2015.pdf?ua=1&ua=1. Accessed November 2, 2018.

17. WHO. *MPOWER IN ACTION Defeating the Global Tobacco Epidemic.*; 2013. http://www.who.int/tobacco/mpower/publications/mpower_2013.pdf?ua=1. Accessed November 5, 2018.
18. Bilano V, Gilmour S, Moffiet T, et al. Global trends and projections for tobacco use, 1990–2025: an analysis of smoking indicators from the WHO Comprehensive Information Systems for Tobacco Control. *Lancet*. 2015;385(9972):966-976. doi:10.1016/S0140-6736(15)60264-1
19. West R. Tobacco smoking: Health impact, prevalence, correlates and interventions. *Psychol Health*. 2017;32(8):1018-1036. doi:10.1080/08870446.2017.1325890
20. Gowing LR, Ali RL, Allsop S, et al. Global statistics on addictive behaviours: 2014 status report. *Addiction*. 2015;110(6):904-919. doi:10.1111/add.12899
21. David A, Esson K, Perucic AM, Fitzpatrick C. Tobacco use: equity and social determinants. Equity. *Soc Determ Public Heal Program*. 2010;199.
22. Kostova D, Chaloupka FJ, Yurekli A, et al. A cross-country study of cigarette prices and affordability: evidence from the Global Adult Tobacco Survey. *Tob Control*. 2014;23(1):e3-e3.
23. Jha P, Peto R, Zatonski W, Boreham J, Jarvis MJ, Lopez AD. Social inequalities in male mortality, and in male mortality from smoking: indirect estimation from national death rates in England and Wales, Poland, and North America. *Lancet*. 2006;368(9533):367-370. doi:10.1016/S0140-6736(06)68975-7
24. Krieger N, Williams DR, Moss NE. Measuring Social Class in US Public Health Research: Concepts, Methodologies, and Guidelines. *Annu Rev Public Health*. 1997;18(1):341-378. doi:10.1146/annurev.publhealth.18.1.341
25. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). *J Epidemiol Community Health*. 2006;60(1):7-12. doi:10.1136/jech.2004.023531
26. Paul Niblett. *Statistics on Smoking - England , 2019 - NHS Digital.*; 2019. https://digital.nhs.uk/data-and-information/publications/statistical/statistics-on-smoking/statistics-on-smoking-england-2019. Accessed August 9, 2018.
27. Fidler JA, Shahab L, West O, et al. “The smoking toolkit study”: a national study of smoking and smoking cessation in England. *BMC Public Health*. 2011;11:479. doi:10.1186/1471-2458-11-479
28. NHS Digital. *Statistics on Smoking: England, 2007.*; 2007.

https://files.digital.nhs.uk/publicationimport/pub00xxx/pub00666/smok-eng-2007-rep.pdf. Accessed November 2, 2018.

29. The Institute of Health Equity. *Fair Society, Healthy Lives The Marmot Review*. http://www.instituteofhealthequity.org/resources-reports/fair-society-healthy-lives-the-marmot-review/fair-society-healthy-lives-full-report-pdf.pdf. Accessed November 2, 2018.
30. Lantz PM, Jacobson PD, Warner KE, et al. Investing in youth tobacco control: a review of smoking prevention and control strategies. *Tob Control*. 2000;9(1):47-63. doi:10.1136/tc.9.1.47
31. Kotz D, West R. Explaining the social gradient in smoking cessation: it's not in the trying, but in the succeeding. *Tob Control*. 2009;18(1):43-46. doi:10.1136/tc.2008.025981
32. Amos A, Hastings G, Angus K, Bostock Y, Fidler J. *A Review of Young People and Smoking in England*. York: Public Health Research Consortium; 2009.
33. Simons-Morton BG, Farhat T. Recent Findings on Peer Group Influences on Adolescent Smoking. *J Prim Prev*. 2010;31(4):191-208. doi:10.1007/s10935-010-0220-x
34. Brook JS, Duan T, Brook DW, Ning Y. Pathways to Nicotine Dependence in African American and Puerto Rican Young Adults. *Am J Addict*. 2007;16(6):450-456. doi:10.1080/10550490701641132
35. Hu TW, Lin Z, Keeler TE. Teenage smoking, attempts to quit, and school performance. *Am J Public Health*. 1998;88(6):940-943. doi:10.2105/AJPH.88.6.940
36. Siahpush M, Jones PR, Singh GK, Timsina LR, Martin J. Association of availability of tobacco products with socio-economic and racial/ethnic characteristics of neighbourhoods. *Public Health*. 2010;124(9):525-529. doi:10.1016/J.PUHE.2010.04.010
37. Marashi-Pour S, Cretikos M, Lyons C, Rose N, Jalaludin B, Smith J. The association between the density of retail tobacco outlets, individual smoking status, neighbourhood socioeconomic status and school locations in New South Wales, Australia. *Spat Spatiotemporal Epidemiol*. 2015;12:1-7. doi:10.1016/J.SSTE.2014.09.001
38. Pennanen M, Broms U, Korhonen T, et al. Smoking, nicotine dependence and nicotine intake by socio-economic status and marital status. *Addict Behav*.

2014;39(7):1145-1151. doi:10.1016/J.ADDBEH.2014.03.005
39. Siahpush M, McNeill A, Borland R, Fong GT. Socioeconomic variations in nicotine dependence, self-efficacy, and intention to quit across four countries: findings from the International Tobacco Control (ITC) Four Country Survey. *Tob Control*. 2006;15 Suppl 3(suppl 3):iii71-5. doi:10.1136/tc.2004.008763
40. Sheffer C, MacKillop J, McGeary J, et al. Delay Discounting, Locus of Control, and Cognitive Impulsiveness Independently Predict Tobacco Dependence Treatment Outcomes in a Highly Dependent, Lower Socioeconomic Group of Smokers. *Am J Addict*. 2012;21(3):221-232. doi:10.1111/j.1521-0391.2012.00224.x
41. Lindström M, Hanson BS, Östergren P-O, Berglund G. Socioeconomic differences in smoking cessation: the role of social participation. *Scand J Public Health*. 2000;28(3):200-208. doi:10.1177/14034948000280030901
42. Meijer E, Gebhardt WA, Van Laar C, Kawous R, Beijk SCAM. Socio-economic status in relation to smoking: The role of (expected and desired) social support and quitter identity. *Soc Sci Med*. 2016;162:41-49. doi:10.1016/J.SOCSCIMED.2016.06.022
43. Pisinger C, Aadahl M, Toft U, Jørgensen T. Motives to quit smoking and reasons to relapse differ by socioeconomic status. *Prev Med (Baltim)*. 2011;52(1):48-52. doi:10.1016/J.YPMED.2010.10.007
44. Brown-Johnson CG, England LJ, Glantz SA, Ling PM. Tobacco industry marketing to low socioeconomic status women in the USA. *Tob Control*. 2014;23(e2):e139-e146. doi:10.1136/tobaccocontrol-2013-051224
45. Burns EK, Levinson AH. Discontinuation of Nicotine Replacement Therapy Among Smoking-Cessation Attempters. *Am J Prev Med*. 2008;34(3):212-215. doi:10.1016/J.AMEPRE.2007.11.010
46. Hiscock R, Bauld L, Amos A, Fidler JA, Munafò M, Munafò M. Socioeconomic status and smoking: a review. *Ann N Y Acad Sci*. 2012;1248(1):107-123. doi:10.1111/j.1749-6632.2011.06202.x
47. Bartley M. *Health Inequality: An Introduction to Concepts, Theories and Methods*. John Wiley & Sons; 2016.
48. Gray AM. Inequalities in Health. The Black Report: A Summary and Comment. *Int J Heal Serv*. 1982;12(3):349-380. doi:10.2190/xxmm-jmqu-2a7y-hx1e
49. Marmot M. Health equity in England: The Marmot review 10 years on. *BMJ*.

2020;368. doi:10.1136/bmj.m693
50. Thomas S, Fayter D, Misso K, et al. Population tobacco control interventions and their effects on social inequalities in smoking: systematic review. *Tob Control*. 2008;17(4):230-237. doi:10.1136/tc.2007.023911
51. Wilkinson AL, Scollo MM, Wakefield MA, Spittal MJ, Chaloupka FJ, Durkin SJ. Articles Smoking prevalence following tobacco tax increases in Australia between 2001 and 2017 : an interrupted time-series analysis. *Lancet Public Heal*. 2019;2667(19):1-10. doi:10.1016/S2468-2667(19)30203-8
52. Aveyard P, Raw M. Improving smoking cessation approaches at the individual level. *Tob Control*. 2012;21(2):252-257. doi:10.1136/tobaccocontrol-2011-050348
53. Hughes J. Effects of abstinence from tobacco: Valid symptoms and time course. *Nicotine Tob Res*. 2007;9(3):315-327. doi:10.1080/14622200701188919
54. Hughes J. Effects of abstinence from tobacco: Etiology, animal models, epidemiology, and significance: A subjective review. *Nicotine Tob Res*. 2007;9(3):329-339. doi:10.1080/14622200701188927
55. Hughes JR, Keely J, Naud S. Shape of the relapse curve and long-term abstinence among untreated smokers. *Addiction*. 2004;99(1):29-38. doi:10.1111/j.1360-0443.2004.00540.x
56. Dobbie F, Hiscock R, Leonardi-Bee J, et al. Evaluating Long-term Outcomes of NHS Stop Smoking Services (ELONS): a prospective cohort study. *Health Technol Assess (Rockv)*. 2015;19(95):1-156. doi:10.3310/hta19950
57. Bauld L, Hiscock R, Dobbie F, et al. English Stop-Smoking Services: One-Year Outcomes. *Int J Environ Res Public Health*. 2016;13(12):1175. doi:10.3390/ijerph13121175
58. Sniehotta FF, Araújo-Soares V, Brown J, Kelly MP, Michie S, West R. Complex systems and individual-level approaches to population health: a false dichotomy? *Lancet Public Heal*. 2017;2(9):e396-e397. doi:10.1016/S2468-2667(17)30167-6
59. Mcewan A. *Standard Treatment Programme: A Guide to Providing Behavioural Support for Smoking Cessation*.; 2014. www.ncsct.co.uk. Accessed November 6, 2018.
60. Benowitz NL, Jacob III P, Ahijevych K, et al. Biochemical verification of tobacco use and cessation. *Nicotine Tob Res*. 2002;4(2).
61. Lancaster T, Stead LF. Individual behavioural counselling for smoking cessation.

Cochrane Database Syst Rev. March 2017. doi:10.1002/14651858.CD001292.pub3

62. Stead LF, Carroll AJ, Lancaster T. Group behaviour therapy programmes for smoking cessation. *Cochrane Database Syst Rev*. 2017;(3). doi:10.1002/14651858.CD001007.pub3
63. Miller WR, Rollnick S. *Motivational Interviewing: Helping People Change*. Guilford press; 2012.
64. Lindson-Hawley N, Thompson TP, Begh R. Motivational interviewing for smoking cessation. *Cochrane Database Syst Rev*. 2015;(3). doi:10.1002/14651858.CD006936.pub3
65. Horan B. *Workforce and Facilities, NHS Digital Responsible Statistician: NHS Workforce Statistics Key Findings*.; 2018. www.statisticsauthority.gov.uk/assessment/code-of-practice. Accessed November 6, 2018.
66. Rice VH, Heath L, Livingstone-Banks J, Hartmann-Boyce J. Nursing interventions for smoking cessation. *Cochrane Database Syst Rev*. 2017;(12). doi:10.1002/14651858.CD001188.pub5
67. Critchley JA, Capewell S. Smoking cessation for the secondary prevention of coronary heart disease. In: Critchley JA, ed. *Cochrane Database of Systematic Reviews*. Chichester, UK: John Wiley & Sons, Ltd; 2003. doi:10.1002/14651858.CD003041.pub2
68. Taylor KL, Cox LS, Zincke N, Mehta L, McGuire C, Gelmann E. Lung cancer screening as a teachable moment for smoking cessation. *Lung Cancer*. 2007;56(1):125-134. doi:10.1016/J.LUNGCAN.2006.11.015
69. T. L, Lancaster T, Stead L, T. L. Physician advice for smoking cessation. *Cochrane Database Syst Rev*. 2004;(4):CD000165. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed9&NEWS=N&AN=39704036.
70. Michie S, Hyder N, Walia A, West R. Development of a taxonomy of behaviour change techniques used in individual behavioural support for smoking cessation. *Addict Behav*. 2011;36(4):315-319. doi:10.1016/j.addbeh.2010.11.016
71. Lorencatto F, West R, Michie S. Specifying Evidence-Based Behavior Change Techniques to Aid Smoking Cessation in Pregnancy. *Nicotine Tob Res*. 2012;14(9):1019-1026. doi:10.1093/ntr/ntr324

72. Lorencatto F, West R, Christopherson C, Michie S. Assessing fidelity of delivery of smoking cessation behavioural support in practice. *Implement Sci*. 2013;8(1):40. doi:10.1186/1748-5908-8-40
73. de Bruin M, Viechtbauer W, Eisma MC, et al. Identifying effective behavioural components of Intervention and Comparison group support provided in SMOKing cEssation (IC-SMOKE) interventions: a systematic review protocol. *Syst Rev*. 2016;5(1):77. doi:10.1186/s13643-016-0253-1
74. Ferguson J, Bauld L, Chesterman J, Judge K. The English smoking treatment services: one-year outcomes. *Addiction*. 2005;100:59-69. doi:10.1111/j.1360-0443.2005.01028.x
75. Stead LF, Koilpillai P, Lancaster T. Additional behavioural support as an adjunct to pharmacotherapy for smoking cessation. *Cochrane Database Syst Rev*. 2015;(10). doi:10.1002/14651858.CD009670.pub3
76. Iacobucci G. Stop smoking services: BMJ analysis shows how councils are stubbing them out. *BMJ*. 2018;362:k3649. doi:10.1136/bmj.k3649
77. Lorencatto F, West R, Bruguera C, Michie S. A method for assessing fidelity of delivery of telephone behavioral support for smoking cessation. *J Consult Clin Psychol*. 2014;82(3):482.
78. Lorencatto F, West R, Bruguera C, Brose LS, Michie S. Assessing the Quality of Goal Setting in Behavioural Support for Smoking Cessation and its Association with Outcomes. *Ann Behav Med*. 2016;50(2):310-318. doi:10.1007/s12160-015-9755-7
79. Stead LF, Hartmann-Boyce J, Perera R, Lancaster T. Telephone counselling for smoking cessation. *Cochrane Database Syst Rev*. 2013;(8). doi:10.1002/14651858.CD002850.pub3
80. Office for National Statistics (ONS). *Internet Access – Households and Individuals, Great Britain - Office for National Statistics*.; 2018. https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/bulletins/internetaccesshouseholdsandindividuals/2018#mobile-phones-or-smartphones-still-most-popular-devices-used-to-access-the-internet. Accessed November 7, 2018.
81. Deloitte. *Deloitte Global Mobile Consumer Survey*.; 2017. https://www2.deloitte.com/uk/en/pages/press-releases/articles/uk-public-glued-to-smartphones.html. Accessed November 7, 2018.

82. Shahab L, McEwen A. Online support for smoking cessation: a systematic review of the literature. *Addiction*. 2009;104(11):1792-1804. doi:10.1111/j.1360-0443.2009.02710.x
83. Graham AL, Carpenter KM, Cha S, et al. Systematic review and meta-analysis of Internet interventions for smoking cessation among adults. *Subst Abuse Rehabil*. 2016;7:55-69. doi:10.2147/SAR.S101660
84. Taylor GMJ, Dalili MN, Semwal M, Civljak M, Sheikh A, Car J. Internet-based interventions for smoking cessation. *Cochrane Database Syst Rev*. 2017;(9). doi:10.1002/14651858.CD007078.pub5
85. Whittaker R, McRobbie H, Bullen C, Rodgers A, Gu Y, Dobson R. Mobile phone text messaging and app-based interventions for smoking cessation. *Cochrane Database Syst Rev*. 2019;2019(10). doi:10.1002/14651858.CD006611.pub5
86. Perski O, Blandford A, West R, Michie S. Conceptualising engagement with digital behaviour change interventions: a systematic review using principles from critical interpretive synthesis. *Transl Behav Med*. 2017;7(2):254-267. doi:10.1007/s13142-016-0453-1
87. Perski O, Blandford A, Ubhi HK, West R, Michie S. Smokers' and drinkers' choice of smartphone applications and expectations of engagement: a think aloud and interview study. *BMC Med Inform Decis Mak*. 2017;17(1):25. doi:10.1186/s12911-017-0422-8
88. Morrison L, Moss-Morris R, Michie S, Yardley L. Optimizing engagement with Internet-based health behaviour change interventions: Comparison of self-assessment with and without tailored feedback using a mixed methods approach. *Br J Health Psychol*. 2014;19(4):839-855. doi:10.1111/bjhp.12083
89. Hartmann-Boyce J, Lancaster T, Stead LF. Print-based self-help interventions for smoking cessation. *Cochrane Database Syst Rev*. 2014;(6). doi:10.1002/14651858.CD001118.pub3
90. Notley C, Gentry S, Livingstone-Banks J, Bauld L, Perera R, Hartmann-Boyce J. Incentives for smoking cessation. *Cochrane Database Syst Rev*. July 2019. doi:10.1002/14651858.CD004307.pub6
91. Halpern SD, French B, Small DS, et al. Randomized Trial of Four Financial-Incentive Programs for Smoking Cessation. *N Engl J Med*. 2015;372(22):2108-2117. doi:10.1056/NEJMoa1414293

92. Halpern SD, French B, Small DS, et al. Heterogeneity in the effects of reward- and deposit-based financial incentives on smoking cessation. *Am J Respir Crit Care Med*. 2016;194(8):981-988. doi:http://dx.doi.org/10.1164/rccm.201601-0108OC
93. Aubin H-J, Luquiens A, Berlin I. Pharmacotherapy for smoking cessation: pharmacological principles and clinical practice. *Br J Clin Pharmacol*. 2014;77(2):324-336. doi:10.1111/bcp.12116
94. Edens E, Massa A, Petrakis I. Novel Pharmacological Approaches to Drug Abuse Treatment. In: Springer, Berlin, Heidelberg; 2010:343-386. doi:10.1007/7854_2009_29
95. Berlin I. Therapeutic strategies to optimize the efficacy of nicotine replacement therapies. *COPD J Chronic Obstr Pulm Dis*. 2009;6(4):272-276.
96. Tulloch HE, Pipe AL, Els C, Clyde MJ, Reid RD. Flexible, dual-form nicotine replacement therapy or varenicline in comparison with nicotine patch for smoking cessation: a randomized controlled trial. *BMC Med*. 2016;14(1):80. doi:10.1186/s12916-016-0626-2
97. Rollema H, Chambers LK, Coe JW, et al. Pharmacological profile of the α4β2 nicotinic acetylcholine receptor partial agonist varenicline, an effective smoking cessation aid. *Neuropharmacology*. 2007;52(3):985-994. doi:10.1016/J.NEUROPHARM.2006.10.016
98. Marubio LM, Gardier AM, Durier S, et al. Effects of nicotine in the dopaminergic system of mice lacking the alpha4 subunit of neuronal nicotinic acetylcholine receptors. *Eur J Neurosci*. 2003;17(7):1329-1337. doi:10.1046/j.1460-9568.2003.02564.x
99. Maskos U, Molles BE, Pons S, et al. Nicotine reinforcement and cognition restored by targeted expression of nicotinic receptors. *Nature*. 2005;436(7047):103-107. doi:10.1038/nature03694
100. Rose JE, Levin ED. Concurrent agonist-antagonist administration for the analysis and treatment of drug dependence. *Pharmacol Biochem Behav*. 1992;41(1):219-226. http://www.ncbi.nlm.nih.gov/pubmed/1539072. Accessed November 8, 2018.
101. Cahill K, Lindson-Hawley N, Thomas KH, Fanshawe TR, Lancaster T. Nicotine receptor partial agonists for smoking cessation. In: Lindson-Hawley N, ed. *Cochrane Database of Systematic Reviews*. Chichester, UK: John Wiley & Sons,

Ltd; 2016. doi:10.1002/14651858.CD006103.pub7

102. Hajek P, Mcrobbie H, Myers K. Efficacy of cytisine in helping smokers quit: systematic review and meta-analysis. *Thorax*. 2012;68(11). doi:10.1136/thoraxjnl-2012-203035

103. Walker N, Howe C, Glover M, et al. Cytisine versus nicotine for smoking cessation. *N Engl J Med*. 2014;371(25):2353-2362. doi:10.1056/NEJMoa1407764

104. Glassman AH, Helzer JE, Covey LS, et al. Smoking, Smoking Cessation, and Major Depression. *JAMA*. 1990;264(12):1546. doi:10.1001/jama.1990.03450120058029

105. Hughes JR, Stead LF, Hartmann-Boyce J, Cahill K, Lancaster T. Antidepressants for smoking cessation. *Cochrane Database Syst Rev*. 2014;(1). doi:10.1002/14651858.CD000031.pub4

106. Stead LF, Koilpillai P, Fanshawe TR, Lancaster T. Combined pharmacotherapy and behavioural interventions for smoking cessation. *Cochrane Database Syst Rev*. 2016;(3). doi:10.1002/14651858.CD008286.pub3

107. NICE. *National Institute for Health and Care Excellence Smoking Cessation Interventions and Services [B] Evidence Reviews for Interventions to Aid Smoking Cessation: Behavioural Support and Pharmacotherapy NICE Guideline NG92 Evidence Reviews*.; 2018. https://www.nice.org.uk/guidance/ng92/evidence/b-interventions-to-aid-smoking-cessation-behavioural-support-and-pharmacotherapy-pdf-4788920847. Accessed November 9, 2018.

108. Cahill K, Stevens S, Perera R, Lancaster T. Pharmacological interventions for smoking cessation: an overview and network meta-analysis. *Cochrane Database Syst Rev*. May 2013. doi:10.1002/14651858.CD009329.pub2

109. Hartmann-Boyce J, Chepkin SC, Ye W, Bullen C, Lancaster T. Nicotine replacement therapy versus control for smoking cessation. *Cochrane Database Syst Rev*. 2018;2018(5). doi:10.1002/14651858.CD000146.pub5

110. Marmot M, Friel S, Bell R, Houweling TA, Taylor S. Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet*. 2008;372(9650):1661-1669. doi:10.1016/S0140-6736(08)61690-6

111. Kotz D, Brown J, West R. ‘Real-world’ effectiveness of smoking cessation treatments: a population study. *Addiction*. 2014;109(3):491-499.

doi:10.1111/add.12429

112. White M, Adams J, Heywood P. *How and Why Do Interventions That Increase Health Overall Widen Inequalities within Populations? In Babones.Social Inequality and Public Health*. Bristol: Policy Press; 2009. http://www.mrc-epid.cam.ac.uk/wp-content/uploads/2016/10/WhiteM_etal_How_and_why_do_interventions_that_increase_health_overall_widen_inequalities_within_populations.pdf. Accessed November 9, 2018.

113. Hiscock R, Dobbie F, Bauld L. Smoking cessation and socioeconomic status: An update of existing evidence from a national evaluation of english stop smoking services. *Biomed Res Int*. 2015;2015. doi:10.1155/2015/274056

114. Hill S, Amos A, Clifford D, Platt S. Impact of tobacco control interventions on socioeconomic inequalities in smoking: review of the evidence. *Tob Control*. 2014;23(e2):e89-97. doi:10.1136/tobaccocontrol-2013-051110

115. Smith CE, Hill SE, Amos A. Impact of specialist and primary care stop smoking support on socio-economic inequalities in cessation in the United Kingdom: a systematic review and national equity initial review completed 22 January 2019; final version accepted 19 July 2019 analysis. *Addiction*. 2020;115(1):34-46. doi:10.1111/add.14760

116. Smith C, Hill S, Amos A. *Stop Smoking Inequalities: A Systematic Review of Socioeconomic Inequalities in Experiences of Smoking Cessation Interventions in The UK*.; 2018. http://www.cancerresearchuk.org/. Accessed September 3, 2018.

117. Boland VC, Stockings EA, Mattick RP, McRobbie H, Brown J, Courtney RJ. The Methodological Quality and Effectiveness of Technology-Based Smoking Cessation Interventions for Disadvantaged Groups: a Systematic Review and Meta-Analysis. *Nicotine Tob Res*. 2016;20(3):ntw391. doi:10.1093/ntr/ntw391

118. Brown J, Michie S, Geraghty AW, et al. Internet-based intervention for smoking cessation (StopAdvisor) in people with low and high socioeconomic status: a randomised controlled trial. *Lancet Respir Med*. 2014;2(12):997-1006. doi:10.1016/S2213-2600(14)70195-X

119. Murray RL, Bauld L, Hackshaw LE, McNeill A. Improving access to smoking cessation services for disadvantaged groups: a systematic review. *J Public Health (Bangkok)*. 2009;31(2):258-277. doi:10.1093/pubmed/fdp008

120. Cancer Research UK and Action on Smoking and Health. *Feeling the Heat: The*

Decline of Stop Smoking Services in England Findings from a Survey of Local Authority Tobacco Control Leads.; 2018. https://www.cancerresearchuk.org/sites/default/files/la_survey_report_2017.pdf. Accessed November 9, 2018.
121. Mcneill A, Brose LS, Calder R, Bauld L, Robson D. *Evidence Review of E-Cigarettes and Heated Tobacco Products 2018 A Report Commissioned by Public Health England*.; 2018. www.facebook.com/PublicHealthEngland. Accessed November 11, 2018.
122. Shahab L, Goniewicz ML, Blount BC, et al. Nicotine, Carcinogen, and Toxin Exposure in Long-Term E-Cigarette and Nicotine Replacement Therapy Users. *Ann Intern Med*. 2017;166(6):390. doi:10.7326/M16-1107
123. Stephens WE. Comparing the cancer potencies of emissions from vapourised nicotine products including e-cigarettes with those of tobacco smoke. *Tob Control*. 2017;27(1):10-17. doi:10.1136/tobaccocontrol-2017-053808
124. Gravely S, Fong G, Cummings K, et al. Awareness, Trial, and Current Use of Electronic Cigarettes in 10 Countries: Findings from the ITC Project. *Int J Environ Res Public Health*. 2014;11(11):11691-11704. doi:10.3390/ijerph111111691
125. World Health Organisation. E-cigarettes: how risky are they? https://www.who.int/news-room/q-a-detail/e-cigarettes-how-risky-are-they. Published 2020. Accessed January 23, 2020.
126. The Tobacco Atlas. Regulating Novel Products – Tobacco Atlas. https://tobaccoatlas.org/topic/regulating-novel-products/. Published 2018. Accessed January 23, 2020.
127. Dept. of Health and Social Care. Guidance: Article 20(5), Tobacco Products Directive: restrictions on advertising electronic cigarettes. https://www.gov.uk/government/publications/proposals-for-uk-law-on-the-advertising-of-e-cigarettes/publishing-20-may-not-yet-complete. Published 2016. Accessed July 31, 2018.
128. Hartmann-Boyce J, McRobbie H, Bullen C, Begh R, Stead LF, Hajek P. Electronic cigarettes for smoking cessation. In: Hartmann-Boyce J, ed. *Cochrane Database of Systematic Reviews*. Chichester, UK: John Wiley & Sons, Ltd; 2016. doi:10.1002/14651858.CD010216.pub3
129. Yong H-H, Hitchman SC, Cummings KM, et al. Does the Regulatory

Environment for E-Cigarettes Influence the Effectiveness of E-Cigarettes for Smoking Cessation?: Longitudinal Findings From the ITC Four Country Survey. *Nicotine Tob Res*. 2017;19(11):1268-1276. doi:10.1093/ntr/ntx056

130. ASA. *Claims about Health in Ads for E-Cigarettes CAP and BCAP's Regulatory Statement*. London; 2018. https://www.asa.org.uk/resource/electronic-cigarette-advertising-prohibition.html. Accessed November 12, 2018.

131. Brown J, West R. *Latest Trends on Smoking in England from the Smoking Toolkit Study*. London; 2019. www.smokinginengland.info/latest-statistics.

132. Cahn Z, Siegel M. Electronic cigarettes as a harm reduction strategy for tobacco control: A step forward or a repeat of past mistakes? *J Public Health Policy*. 2011;32(1):16-31. doi:10.1057/jphp.2010.41

133. Notley C, Ward E, Dawkins L, Holland R. The unique contribution of e-cigarettes for tobacco harm reduction in supporting smoking relapse prevention. *Harm Reduct J*. 2018;15(1):31. doi:10.1186/s12954-018-0237-7

134. Hajek P, Etter J-F, Benowitz N, Eissenberg T, Mcrobbie H. Electronic cigarettes: review of use, content, safety, effects on smokers and potential for harm and benefit. *Addiction*. 2014;109(11):1801-1810. doi:10.1111/add.12659

135. Hajek P, Przulj D, Phillips A, Anderson R, McRobbie H. Nicotine delivery to users from cigarettes and from different types of e-cigarettes. *Psychopharmacology (Berl)*. 2017;234(5):773-779. doi:10.1007/s00213-016-4512-6

136. Hitchman SC, Brose LS, Brown J, Robson D, McNeill A. Associations Between E-Cigarette Type, Frequency of Use, and Quitting Smoking: Findings From a Longitudinal Online Panel Survey in Great Britain. *Nicotine Tob Res*. 2015;17(10):1187-1194. doi:10.1093/ntr/ntv078

137. Dawkins L, Mcrobbie H. *Changing Behaviour: Electronic Cigarettes*. London; 2017. www.bps.org.uk/behaviourchange. Accessed November 26, 2018.

138. Hajek P, Phillips-Waller A, Przulj D, et al. A Randomized Trial of E-Cigarettes versus Nicotine-Replacement Therapy. *N Engl J Med*. 2019;380(7):629-637. doi:10.1056/NEJMoa1808779

139. Walker N, Parag V, Verbiest M, Laking G, Laugesen M, Bullen C. Nicotine patches used in combination with e-cigarettes (with and without nicotine) for smoking cessation: a pragmatic, randomised trial. *Lancet Respir Med*. September 2019. doi:10.1016/s2213-2600(19)30269-3

140. Beard E, Jackson SE, West R, Kuipers MAG, Brown J. Population-level predictors of changes in success rates of smoking quit attempts in England: a time series analysis. *Addiction*. December 2019:add.14837. doi:10.1111/add.14837
141. Beard E, West R, Michie S, Brown J. Association between electronic cigarette use and changes in quit attempts, success of quit attempts, use of smoking cessation pharmacotherapy, and use of stop smoking services in England: time series analysis of population trends. *BMJ*. 2016;354:i4645. doi:10.1136/BMJ.I4645
142. Adkison SE, O'Connor RJ, Bansal-Travers M, et al. Electronic Nicotine Delivery Systems: International Tobacco Control Four-Country Survey. *Am J Prev Med*. 2013;44(3):207-215. doi:10.1016/J.AMEPRE.2012.10.018
143. Grana RA, Popova L, Ling PM. A Longitudinal Analysis of Electronic Cigarette Use and Smoking Cessation. *JAMA Intern Med*. 2014;174(5):812. doi:10.1001/jamainternmed.2014.187
144. Abrams DB, Glasser AM, Pearson JL, Villanti AC, Collins LK, Niaura RS. Harm Minimization and Tobacco Control: Reframing Societal Views of Nicotine Use to Rapidly Save Lives. *Annu Rev Public Health*. 2018;39(1):193-213. doi:10.1146/annurev-publhealth-040617-013849
145. Soar K, Kimber C, McRobbie H, Dawkins LE. Nicotine absorption from e-cigarettes over 12 months. *Addict Behav*. July 2018. doi:10.1016/J.ADDBEH.2018.07.019
146. Dawkins LE, Kimber CF, Doig M, Feyerabend C, Corcoran O. Self-titration by experienced e-cigarette users: blood nicotine delivery and subjective effects. *Psychopharmacology (Berl)*. 2016;233(15-16):2933-2941. doi:10.1007/s00213-016-4338-2
147. Dawkins L, Cox S, Goniewicz M, et al. 'Real-world' compensatory behaviour with low nicotine concentration e-liquid: subjective effects and nicotine, acrolein and formaldehyde exposure. *Addiction*. 2018;113(10):1874-1882. doi:10.1111/add.14271
148. East K, Hitchman SC, Bakolis I, et al. The Association Between Smoking and Electronic Cigarette Use in a Cohort of Young People. *J Adolesc Health*. 2018;0(0). doi:10.1016/j.jadohealth.2017.11.301
149. Barrington-Trimis JL, Urman R, Berhane K, et al. E-Cigarettes and Future

Cigarette Use. *Pediatrics*. 2016;138(1):e20160379. doi:10.1542/peds.2016-0379
150. Leventhal AM, Strong DR, Kirkpatrick MG, et al. Association of Electronic Cigarette Use With Initiation of Combustible Tobacco Product Smoking in Early Adolescence. *JAMA*. 2015;314(7):700. doi:10.1001/jama.2015.8950
151. Kozlowski LT, Warner KE. Adolescents and e-cigarettes: Objects of concern may appear larger than they are. *Drug Alcohol Depend*. 2017;174:209-214. doi:10.1016/j.drugalcdep.2017.01.001
152. Action on Smoking and Health. Fact Sheets - Action on Smoking and Health. http://ash.org.uk/category/information-and-resources/fact-sheets/. Published 2016. Accessed November 23, 2017.
153. Levy DT, Borland R, Lindblom EN, et al. Potential deaths averted in USA by replacing cigarettes with e-cigarettes. *Tob Control*. 2018;27(1):18-25. doi:10.1136/tobaccocontrol-2017-053759
154. Fairchild AL, Bayer R, Lee JS. The E-Cigarette Debate: What Counts as Evidence? *Am J Public Health*. 2019;109(7):1000-1006. doi:10.2105/AJPH.2019.305107
155. West R, Brown J. Epidemic of youth nicotine addiction? What does the National Youth Tobacco Survey reveal about high school e-cigarette use in the USA? (Preprint). *Qeios*. October 2019. doi:10.32388/745076.2
156. Cullen KA, Gentzke AS, Sawdey MD, et al. E-Cigarette Use among Youth in the United States, 2019. *JAMA - J Am Med Assoc*. December 2019. doi:10.1001/jama.2019.18387
157. Center for Disaease Control and Prevention. New Cases in Outbreak of E-cigarette, or Vaping, Product Use-Associated Lung Injury (EVALI) On the Decline | CDC Online Newsroom | CDC. https://www.cdc.gov/media/releases/2019/p1220-cases-EVALI.html. Published 2019. Accessed January 23, 2020.
158. Tattan-Birch H, Brown J, Shahab L, Jackson S. Association of the US Outbreak of Vaping-Associated Lung Injury With Perceived Harm of e-Cigarettes Compared With Cigarettes. *JAMA Netw Open*. 2020;3(6):6. doi:10.1001/jamanetworkopen.2020.6981
159. Foundation for a Smoke-Free World. *Global Trends in Nicotine*.; 2018. https://www.smokefreeworld.org. Accessed November 12, 2018.
160. McDaniel PA, Smith EA, Malone RE. Philip Morris's Project Sunrise:

weakening tobacco control by working with it. *Tob Control*. 2006;15(3):215-223.

161. Green LW, Fielding JE, Brownson RC. The Debate About Electronic Cigarettes: Harm Minimization or the Precautionary Principle. *Annu Rev Public Health*. 2018;39(1):189-191. doi:10.1146/annurev-publhealth-102417-124810

162. Hendlin YH, Elias J, Ling PM. The Pharmaceuticalization of the Tobacco Industry. *Ann Intern Med*. 2017;167(4):278. doi:10.7326/M17-0759

163. Levy DT, Cummings KM, Villanti AC, et al. A framework for evaluating the public health impact of e-cigarettes and other vaporized nicotine products. *Addiction*. 2017;112(1):8-17. doi:10.1111/add.13394

164. Hartwell G, Thomas S, Egan M, Gilmore A, Petticrew M. E-cigarettes and equity: a systematic review of differences in awareness and use between sociodemographic groups. *Tob Control*. December 2016:tobaccocontrol-2016-053222. doi:10.1136/tobaccocontrol-2016-053222

165. Brown J, West R, Beard E, Michie S, Shahab L, McNeill A. Prevalence and characteristics of e-cigarette users in Great Britain: Findings from a general population survey of smokers. *Addict Behav*. 2014;39(6):1120-1125. doi:10.1016/J.ADDBEH.2014.03.009

166. Rogers E. Diffusion of Innovations, 5th (fifth) edition. 2004.

167. Thirlway F. How will e-cigarettes affect health inequalities? Applying Bourdieu to smoking and cessation. *Int J Drug Policy*. 2018;54:99-104. doi:10.1016/j.drugpo.2018.01.009

168. Dawkins L, Ford A, Bauld L, Balaban S, Tyler A, Cox S. A cross sectional survey of smoking characteristics and quitting behaviour from a sample of homeless adults in Great Britain. *Addict Behav*. 2019;95:35-40. doi:10.1016/j.addbeh.2019.02.020

169. Friedman AS, Horn SJL. Socioeconomic Disparities in Electronic Cigarette Use and Transitions from Smoking. *Nicotine Tob Res*. June 2018. doi:10.1093/ntr/nty120

170. Harlow AF, Stokes A, Brooks DR. Socioeconomic and Racial/Ethnic Differences in E-Cigarette Uptake Among Cigarette Smokers: Longitudinal Analysis of the Population Assessment of Tobacco and Health (PATH) Study. *Nicotine Tob Res*. July 2018. doi:10.1093/ntr/nty141

171. Greenhalgh E, Bayly M, Winstanley M. 1.7 Trends in the prevalence of smoking by socio-economic status - Tobacco In Australia. Tobacco in Australia: Facts &

Issues. http://www.tobaccoinaustralia.org.au/1-7-trends-in-the-prevalence-of-smoking-by-socioec. Published 2017. Accessed June 18, 2018.

172. Jamal A, Phillips E, Gentzke AS, et al. Current Cigarette Smoking Among Adults — United States, 2016. CDC Morbidity and Mortality Weekly Report. doi:10.15585/mmwr.mm6702a1

173. West R. The Multiple Facets of Cigarette Addiction and What They Mean for Encouraging and Helping Smokers to Stop. *COPD J Chronic Obstr Pulm Dis*. 2009;6:277-283. doi:10.1080/15412550903049181

174. Rutter H, Savona N, Glonti K, et al. The need for a complex systems model of evidence for public health. *Lancet*. 2017;390(10112):2602-2604. doi:10.1016/S0140-6736(17)31267-9

175. Vrijheid M. The exposome: a new paradigm to study the impact of environment on health. *Thorax*. 2014;69(9):876-878. doi:10.1136/thoraxjnl-2013-204949

176. Graham H, Kelly M. *Health Inequalities: Concepts, Frameworks and Policy*.; 2011. https://www.k4health.org/sites/default/files/health_inequalities_concepts.pdf. Accessed June 19, 2018.

177. West R, Baker CL, Cappelleri JC, Bushmakin AG. Effect of varenicline and bupropion SR on craving, nicotine withdrawal symptoms, and rewarding effects of smoking during a quit attempt. *Psychopharmacology (Berl)*. 2008;197(3):371-377. doi:10.1007/s00213-007-1041-3

178. Michie S, van Stralen MM, West R. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implement Sci*. 2011;6(1):42. doi:10.1186/1748-5908-6-42

179. Chua HF, Ho SS, Jasinska AJ, et al. Self-related neural response to tailored smoking-cessation messages predicts quitting. *Nat Neurosci*. 2011;14(4):426-427. doi:10.1038/nn.2761

180. Bryant J, Bonevski B, Paul C, McElduff P, Attia J. A systematic review and meta-analysis of the effectiveness of behavioural smoking cessation interventions in selected disadvantaged groups. *Addiction*. 2011;106(9):1568-1585. doi:10.1111/j.1360-0443.2011.03467.x

181. Hiscock R, Murray S, Brose LS, et al. Behavioural therapy for smoking cessation: The effectiveness of different intervention types for disadvantaged and affluent smokers. *Addict Behav*. 2013;38(11):2787-2796.

doi:10.1016/J.ADDBEH.2013.07.010
182. Courtney R, Naicker S, Shakeshaft A, Clare P, Martire K, Mattick R. Smoking Cessation among Low-Socioeconomic Status and Disadvantaged Population Groups: A Systematic Review of Research Output. *Int J Environ Res Public Health*. 2015;12(12):6403-6422. doi:10.3390/ijerph120606403
183. Bauld L, Judge K, Platt S. Assessing the impact of smoking cessation services on reducing health inequalities in England: observational study. *Tob Control*. 2007;16(6):400-404. doi:10.1136/tc.2007.021626
184. Roland M, Torgerson DJ. What are pragmatic trials? *BMJ*. 1998;316(7127):285. doi:10.1136/BMJ.316.7127.285
185. Schünemann H, Brożek J, Oxman GGA. Handbook for grading the quality of evidence and the strength of recommendations using the GRADE approach. 2013. *URL http//gdt Guidel org/app/handbook/handbook html [WebCite Cache ID 6psHGGOvH]*. 2017.
186. Borenstein M, Hedges L V., Higgins JPT, Rothstein HR. Introduction to Meta-Analysis. 2011.
187. Langan D, Higgins JPT, Jackson D, et al. A comparison of heterogeneity variance estimators in simulated random-effects meta-analyses. *Res Synth Methods*. 2019;10(1):83-98. doi:10.1002/jrsm.1316
188. Borenstein M, Hedges L V, Higgins JPT, Rothstein HR. *Meta-Regression*.; 2009. https://www.meta-analysis.com/downloads/Meta-analysis Meta regression.pdf. Accessed November 25, 2018.
189. Bendtsen M. A gentle introduction to the comparison between null hypothesis testing and Bayesian analysis: Reanalysis of two randomized controlled trials. *J Med Internet Res*. 2018;20(10):e10873. doi:10.2196/10873
190. Dienes Z. Using Bayes to get the most out of non-significant results. *Front Psychol*. 2014;5:781. doi:10.3389/fpsyg.2014.00781
191. West R. Using Bayesian analysis for hypothesis testing in addiction science. *Addiction*. 2016;111(1):3-4. doi:10.1111/add.13053
192. Bull ER, Dombrowski SU, McCleary N, Johnston M. Are interventions for low-income groups effective in changing healthy eating, physical activity and smoking behaviours? A systematic review and meta-analysis. *BMJ Open*. 2014;4(11):e006046. doi:10.1136/bmjopen-2014-006046
193. Viechtbauer W. Conducting meta-analyses in R with the metafor package. *J Stat*

Softw. 2010;36(3):1-48. https://lirias.kuleuven.be/1059637?limo=0. Accessed August 21, 2019.

194. Chen D-GD, Peace KE. *Applied Meta-Analysis with R*. Chapman and Hall/CRC; 2013.

195. Higgins JPT, Sterne JAC, Savović J, et al. A revised tool for assessing risk of bias in randomized trials. *Cochrane Database Syst Rev*. 2016;10(Suppl 1):29-31.

196. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315(7109):629-634. doi:10.1136/BMJ.315.7109.629

197. Higgins J, Green S. *Cochrane Handbook for Systematic Reviews of Interventions: Cochrane Book Series*.; 2011. www.wiley.com. Accessed April 18, 2019.

198. Curry SJ, Ludman EJ, Graham E, Stout J, Grothaus L, Lozano P. Pediatric-based smoking cessation intervention for low-income women: a randomized trial. *Arch Pediatr Adolesc Med*. 2003;157(3):295-302. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=12622686.

199. Lepore S, Collins B, Coffman D, et al. Kids Safe and Smokefree (KiSS) Multilevel Intervention to Reduce Child Tobacco Smoke Exposure: Long-Term Results of a Randomized Controlled Trial. *Int J Environ Res Public Health*. 2018;15(6):1239. doi:10.3390/ijerph15061239

200. Gordon JS, Andrews JA, Albert DA, Crews KM, Payne TJ, Severson HH. Tobacco cessation via public dental clinics: results of a randomized trial. *Am J Public Health*. 2010;100(7):1307-1312. doi:10.2105/AJPH.2009.181214

201. Berndt N, de Vries H, Lechner L, et al. High intensity smoking cessation interventions: Cardiac patients of low socioeconomic status and low intention to quit profit most. *Netherlands Hear J*. 2017;25(1):24-32. doi:10.1007/s12471-016-0906-7

202. Nohlert E, Tegelberg Å, Tillgren P, Johansson P, Rosenblad A, Helgason ÁR. Comparison of a high and a low intensity smoking cessation intervention in a dentistry setting in Sweden – a randomized trial. *BMC Public Health*. 2009;9(1):121. doi:10.1186/1471-2458-9-121

203. Glasgow RE, Whitlock EP, Eakin EG, Lichtenstein E. A brief smoking cessation intervention for women in low-income planned parenthood clinics. *Am J Public*

Health. 2000;90(5):786-789. http://www.ncbi.nlm.nih.gov/pubmed/10800431. Accessed April 18, 2019.

204. Lasser KE, Quintiliani LM, Truong V, et al. Effect of Patient Navigation and Financial Incentives on Smoking Cessation Among Primary Care Patients at an Urban Safety-Net Hospital. *JAMA Intern Med*. 2017;177(12):1798. doi:10.1001/jamainternmed.2017.4372

205. Yilmaz G, Karacan C, Yoney A, Yilmaz T. Brief intervention on maternal smoking: a randomized controlled trial. *Child Care Health Dev*. 2006;32(1):73-79. doi:10.1111/j.1365-2214.2006.00570.x

206. Stanton WR, Lowe JB, Moffatt J, Del Mar CB. Randomised control trial of a smoking cessation intervention directed at men whose partners are pregnant. *Prev Med (Baltim)*. 2004;38(1):6-9. doi:10.1016/J.YPMED.2003.09.021

207. Pbert L, Ockene JK, Zapka J, et al. A community health center smoking-cessation intervention for pregnant and postpartum women. *Am J Prev Med*. 2004;26(5):377-385. doi:10.1016/J.AMEPRE.2004.02.010

208. Ruger JP, Weinstein MC, Hammond SK, Kearney MH, Emmons KM. Cost-Effectiveness of Motivational Interviewing for Smoking Cessation and Relapse Prevention among Low-Income Pregnant Women: A Randomized Controlled Trial. *Value Heal*. 2008;11(2):191-198. doi:10.1111/j.1524-4733.2007.00240.x

209. Solomon LJ, Scharoun GM, Flynn BS, Secker-Walker RH, Sepinwall D. Free Nicotine Patches plus Proactive Telephone Peer Support to Help Low-Income Women Stop Smoking. *Prev Med (Baltim)*. 2000;31(1):68-74. doi:10.1006/PMED.2000.0683

210. Solomon LJ, Marcy TW, Howe KD, Skelly JM, Reinier K, Flynn BS. Does extended proactive telephone support increase smoking cessation among low-income women using nicotine patches? *Prev Med (Baltim)*. 2005;40(3):306-313. doi:10.1016/J.YPMED.2004.06.005

211. Andrews JO, Mueller M, Dooley M, Newman SD, Magwood GS, Tingen MS. Effect of a smoking cessation intervention for women in subsidized neighborhoods: A randomized controlled trial. *Prev Med (Baltim)*. 2016;90:170-176. doi:10.1016/J.YPMED.2016.07.008

212. Baker TB, Fraser DL, Kobinsky K, et al. A randomized controlled trial of financial incentives to low income pregnant women to engage in smoking cessation treatment: Effects on post-birth abstinence. *J Consult Clin Psychol*.

2018;86(5):464-473. doi:10.1037/ccp0000278

213. Vidrine DJ, Frank-Pearce SG, Vidrine JI, et al. Efficacy of Mobile Phone–Delivered Smoking Cessation Interventions for Socioeconomically Disadvantaged Individuals. *JAMA Intern Med*. 2019;179(2):167. doi:10.1001/jamainternmed.2018.5713

214. Mundt MP, Baker TB, Fraser DL, Smith SS, Piper ME, Fiore MC. Paying Low-Income Smokers to Quit? The Cost-Effectiveness of Incentivizing Tobacco Quit Line Engagement for Medicaid Recipients Who Smoke. *Value Heal*. 2019;22(2):177-184. doi:10.1016/J.JVAL.2018.08.001

215. Okuyemi KS, James AS, Mayo MS, et al. Pathways to Health: A Cluster Randomized Trial of Nicotine Gum and Motivational Interviewing for Smoking Cessation in Low-Income Housing. *Heal Educ Behav*. 2007;34(1):43-54. doi:10.1177/1090198106288046

216. Kendzor DE, Reitzel LR, Mazas CA, et al. Individual- and area-level unemployment influence smoking cessation among African Americans participating in a randomized clinical trial. *Soc Sci Med*. 2012;74(9):1394-1401. doi:10.1016/J.SOCSCIMED.2012.01.013

217. Brooks DR, Burtner JL, Borrelli B, et al. Twelve-Month Outcomes of a Group-Randomized Community Health Advocate-Led Smoking Cessation Intervention in Public Housing. *Nicotine Tob Res*. 2018;20(12):1434-1441. doi:10.1093/ntr/ntx193

218. Fraser DL, Fiore MC, Kobinsky K, et al. A Randomized Trial of Incentives for Smoking Treatment in Medicaid Members. *Am J Prev Med*. 2017;53(6):754-763. doi:10.1016/J.AMEPRE.2017.08.027

219. Froelicher ES, Doolan D, Yerger VB, McGruder CO, Malone RE. Combining community participatory research with a randomized clinical trial: The protecting the hood against tobacco (PHAT) smoking cessation study. *Hear Lung*. 2010;39(1):50-63. doi:10.1016/J.HRTLNG.2009.06.004

220. Sarkar BK, West R, Arora M, Ahluwalia JS, Reddy KS, Shahab L. Effectiveness of a brief community outreach tobacco cessation intervention in India: A cluster-randomised controlled trial (the BABEX Trial). *Thorax*. 2017;72(2):167-173. doi:10.1136/thoraxjnl-2016-208732

221. Lou P, Zhu Y, Chen P, et al. Supporting smoking cessation in chronic obstructive pulmonary disease with behavioral intervention: a randomized controlled trial.

BMC Fam Pract. 2013;14(1):91. doi:10.1186/1471-2296-14-91

222. Choi SH, Waltje AH, Ronis DL, et al. Web-enhanced tobacco tactics with telephone support versus 1-800-QUIT-NOW telephone line intervention for operating engineers: randomized controlled trial. *J Med Internet Res*. 2014;16(11):e255. doi:10.2196/jmir.3375
223. Fu SS, van Ryn M, Nelson D, et al. Proactive tobacco treatment offering free nicotine replacement therapy and telephone counselling for socioeconomically disadvantaged smokers: a randomised clinical trial. *Thorax*. 2016;71(5):446-453. doi:10.1136/thoraxjnl-2015-207904
224. Davis JM, Manley AR, Goldberg SB, Smith SS, Jorenby DE. Randomized trial comparing mindfulness training for smokers to a matched control. *J Subst Abuse Treat*. 2014;47(3):213-221. doi:https://dx.doi.org/10.1016/j.jsat.2014.04.005
225. Abroms LC, Boal AL, Simmens SJ, Mendel JA, Windsor RA. A Randomized Trial of Text2Quit: A Text Messaging Program for Smoking Cessation. *Am J Prev Med*. 2014;47(3):242-250. doi:10.1016/J.AMEPRE.2014.04.010
226. Bonevski B, Twyman L, Paul C, et al. Smoking cessation intervention delivered by social service organisations for a diverse population of Australian disadvantaged smokers: A pragmatic randomised controlled trial. *Prev Med (Baltim)*. 2018;112:38-44. doi:10.1016/J.YPMED.2018.04.005
227. Danan ER, Fu SS, Clothier BA, et al. The Equity Impact of Proactive Outreach to Smokers: Analysis of a Randomized Trial. *Am J Prev Med*. 2018;55(4):506-516. doi:10.1016/J.AMEPRE.2018.05.023
228. Etter J-F, Schmid F. Effects of Large Financial Incentives for Long-Term Smoking Cessation. *J Am Coll Cardiol*. 2016;68(8):777-785. doi:10.1016/j.jacc.2016.04.066
229. Free C, Knight R, Robertson S, et al. Smoking cessation support delivered via mobile phone text messaging (txt2stop): a single-blind, randomised trial. *Lancet*. 2011;378(9785):49-55. doi:10.1016/S0140-6736(11)60701-0
230. Haas JS, Linder JA, Park ER, et al. Proactive Tobacco Cessation Outreach to Smokers of Low Socioeconomic Status. *JAMA Intern Med*. 2015;175(2):218. doi:10.1001/jamainternmed.2014.6674
231. Marks DF, Sykes CM. Randomized controlled trial of cognitive behavioural therapy for smokers living in a deprived area of London: Outcome at one-year follow-up. *Psychol Health Med*. 2002;7(1):17-24.

doi:10.1080/13548500120101513
232. McClure JB, Bush T, Anderson ML, et al. Oral Health Promotion and Smoking Cessation Program Delivered via Tobacco Quitlines: The Oral Health 4 Life Trial. *Am J Public Health*. 2018;108(5):689-695. doi:10.2105/AJPH.2017.304279
233. Prokhorov A V., Yost T, Mullin-Jones M, et al. “Look At Your Health”: Outcomes associated with a computer-assisted smoking cessation counseling intervention for community college students. *Addict Behav*. 2008;33(6):757-771. doi:10.1016/J.ADDBEH.2007.12.005
234. Rash CJ, Petry NM, Alessi SM. A randomized trial of contingency management for smoking cessation in the homeless. Aidala Alessi, Arnsten, Baggett, Baggett, Baggett, Benishek, Berman, Bonevski, Burling, Businelle, Carpenter, Charpentier, Connor, Eisenberg, Fiore, Harris, Heatherton, Heil, Higgins, Higgins, Higgins, Hwang, Irons, Jones, Lamb, Lamb, Lamb, Lamb, Lussier A, ed. *Psychol Addict Behav*. 2018;32(2):141-148. doi:http://dx.doi.org/10.1037/adb0000350
235. Sheffer CE, Bickel WK, Franck CT, et al. Improving tobacco dependence treatment outcomes for smokers of lower socioeconomic status: A randomized clinical trial. *Drug Alcohol Depend*. 2017;181:177-185. doi:10.1016/J.DRUGALCDEP.2017.09.015
236. Sorensen G, Barbeau EM, Stoddard AM, et al. Tools for health: the efficacy of a tailored intervention targeted for construction laborers. *Cancer Causes Control*. 2007;18(1):51-59. doi:10.1007/s10552-006-0076-9
237. Stanczyk NE, de Vries H, Candel MJJM, Muris JWM, Bolman CAW. Effectiveness of video- versus text-based computer-tailored smoking cessation interventions among smokers after one year. *Prev Med (Baltim)*. 2016;82:42-50. doi:10.1016/J.YPMED.2015.11.002
238. Strecher VJ, McClure J, Alexander G, et al. The role of engagement in a tailored web-based smoking cessation program: randomized controlled trial. *F, P, C, J, V, K, M, R, J, A-M, S, K, … S, K (2003) Predict Attend a randomized Clin trial nicotine Replace Ther with Behav P, C, J, V, K, M, R, J, A-M, S, K, … S, K (2003) Predict*. 2008;10(5):e36. doi:https://dx.doi.org/10.2196/jmir.1002
239. Sterne JAC, Sutton AJ, Ioannidis JPA, et al. Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised

controlled trials. *BMJ*. 2011;343:d4002. doi:10.1136/bmj.d4002

240. Andrews JO, Mueller M, Newman SD, et al. The Association of Individual and Neighborhood Social Cohesion, Stressors, and Crime on Smoking Status Among African-American Women in Southeastern US Subsidized Housing Neighborhoods. *J Urban Heal*. 2014;91(6):1158-1174. doi:10.1007/s11524-014-9911-6
241. Hughes JR, Carpenter MJ, Naud S. Do point prevalence and prolonged abstinence measures produce similar results in smoking cessation studies? A systematic review. *Nicotine Tob Res*. 2010;12(7):756-762. doi:10.1093/ntr/ntq078
242. Walters SJ. Therapist effects in randomised controlled trials: what to do about them. *J Clin Nurs*. 2010;19(7-8):1102-1112. doi:10.1111/j.1365-2702.2009.03067.x
243. Jackson SE, Smith C, Cheeseman H, West R, Brown J. Finding smoking hot-spots: a cross-sectional survey of smoking patterns by housing tenure in England. *Addiction*. 2019;114(5):889-895. doi:10.1111/add.14544
244. Zhu S-H, Zhuang Y-L, Wong S, Cummins SE, Tedeschi GJ. E-cigarette use and associated changes in population smoking cessation: evidence from US current population surveys. *BMJ*. 2017;358:j3262. doi:10.1136/BMJ.J3262
245. Jackson SE, Shahab L, Kock L, West R, Brown J. Expenditure on smoking and alternative nicotine delivery products: a population survey in England. *Addiction*. 2019;114(11):2026-2036. doi:10.1111/add.14709
246. Wagener TL, Floyd EL, Stepanov I, et al. Have combustible cigarettes met their match? The nicotine delivery profiles and harmful constituent exposures of second-generation and third-generation electronic cigarette users. *Tob Control*. 2017;26(e1):e23-e28. doi:10.1136/tobaccocontrol-2016-053041
247. Brand RA. Editorial: Standards of reporting: The consort, quorum, and strobe guidelines. *Clin Orthop Relat Res*. 2009;467(6):1393-1394. doi:10.1007/s11999-009-0786-x
248. NRS. National Readership Survey - Social Grade. http://www.nrs.co.uk/nrs-print/lifestyle-and-classification-data/social-grade/. Published 2017. Accessed November 24, 2017.
249. Department for Communities and Local Government. English Housing Survey: guidance and methodology - GOV.UK. https://www.gov.uk/guidance/english-

housing-survey-guidance-and-methodology#about-the-english-housing-survey. Published 2017. Accessed December 6, 2017.

250. Jackson SE, Kotz D, West R, Brown J. Moderators of real-world effectiveness of smoking cessation aids: a population study. *Addiction*. 2019;114(9):1627-1638. doi:10.1111/add.14656
251. Hiscock R, Arnott D, Dockrell M, Ross L, McEwen A. Stop Smoking Practitioners' understanding of e-cigarettes' use and efficacy with particular reference to vapers' socioeconomic status. *J Smok Cessat*. 2019;14(1):21-31. doi:10.1017/jsc.2018.9
252. Pearson JL, Hitchman SC, Brose LS, et al. Recommended core items to assess e-cigarette use in population-based surveys. *Tob Control*. 2018;27(3):341-346. doi:10.1136/tobaccocontrol-2016-053541
253. Kock L, Shahab L, West R, Brown J. E-cigarette use in England 2014–17 as a function of socio-economic profile. *Addiction*. 2019;114(2):294-303. doi:10.1111/add.14446
254. Action on Smoking and Health. *Use of E-Cigarettes (Vaporisers) among Adults in Great Britain*.; 2019. https://ash.org.uk/information-and-resources/ash-fact-sheets/. Accessed February 24, 2020.
255. Green MJ, Gray L, Sweeting H, Benzeval M. Socioeconomic patterning of vaping by smoking status among UK adults and youth. *BMC Public Health*. 2020;20(1):1-11. doi:10.1186/s12889-020-8270-3
256. Lucherini M, Hill S, Smith K. Potential for non-combustible nicotine products to reduce socioeconomic inequalities in smoking: A systematic review and synthesis of best available evidence. *BMC Public Health*. 2019;19(1):1-12. doi:10.1186/s12889-019-7836-4
257. McNeill A, Driezen P, Hitchman SC, Cummings KM, Fong GT, Borland R. Indicators of cigarette smoking dependence and relapse in former smokers who vape compared with those who do not: findings from the 2016 International Tobacco Control Four Country Smoking and Vaping Survey. *Addiction*. 2019;114(S1):49-60. doi:10.1111/add.14722
258. Stapleton J. Perverse conclusion from results | Tobacco Control. Tobacco Control. https://tobaccocontrol.bmj.com/content/perverse-conclusion-results. Published 2012. Accessed December 17, 2019.
259. McMillen R, Klein JD, Wilson K, Winickoff JP, Tanski S. E-Cigarette Use and

Future Cigarette Initiation Among Never Smokers and Relapse Among Former Smokers in the PATH Study. *Public Health Rep*. 2019;134(5):528-536. doi:10.1177/0033354919864369

260. Everard CD, Silveira ML, Kimmel HL, Marshall D, Blanco C, Compton WM. Association of Electronic Nicotine Delivery System Use With Cigarette Smoking Relapse Among Former Smokers in the United States. *JAMA Netw Open*. 2020;3(6):e204813. doi:10.1001/jamanetworkopen.2020.4813
261. Berry KM, Fetterman JL, Benjamin EJ, et al. Association of Electronic Cigarette Use With Subsequent Initiation of Tobacco Cigarettes in US Youths. *JAMA Netw open*. 2019;2(2):e187794. doi:10.1001/jamanetworkopen.2018.7794
262. Vanyukov MM, Tarter RE, Kirillova GP, et al. Common liability to addiction and "gateway hypothesis": Theoretical, empirical and evolutionary perspective. *Drug Alcohol Depend*. 2012;123(SUPPL.1):S3-S17. doi:10.1016/j.drugalcdep.2011.12.018
263. Action on Smoking and Health. *Use of E-Cigarettes among Young People in Great Britain*.; 2019. http://ash.org.uk/category/information-and-resources/. Accessed November 27, 2019.
264. Wadsworth E, Neale J, McNeill A, Hitchman S. How and Why Do Smokers Start Using E-Cigarettes? Qualitative Study of Vapers in London, UK. *Int J Environ Res Public Health*. 2016;13(7):661. doi:10.3390/ijerph13070661
265. Simmons VN, Quinn GP, Harrell PT, et al. E-cigarette use in adults: A qualitative study of users' perceptions and future use intentions. *Addict Res Theory*. 2016;24(4):313-321. doi:10.3109/16066359.2016.1139700
266. Vasconcelos V, Gilbert H. Smokers' knowledge and perception of electronic cigarettes (e-cigarettes): a qualitative study of non-quitting smokers in a North London general practice. *Prim Heal Care Res Dev*. 2018;20:1-9. doi:10.1017/S1463423618000439
267. Gentry S, Forouhi NG, Notley C. Are Electronic Cigarettes an Effective Aid to Smoking Cessation or Reduction Among Vulnerable Groups? A Systematic Review of Quantitative and Qualitative Evidence. *Nicotine Tob Res*. 2019;21(5):602-616. doi:10.1093/NTR/NTY054
268. Thirlway F. Everyday tactics in local moral worlds: E-cigarette practices in a working-class area of the UK. *Soc Sci Med*. 2016;170:106-113. doi:10.1016/j.socscimed.2016.10.012

269. Shiffman S. How Many Cigarettes Did You Smoke? Assessing Cigarette Consumption by Global Report, Time-Line Follow-Back, and Ecological Momentary Assessment. *Heal Psychol*. 2009;28(5):519-526. doi:10.1037/a0015197

270. Blank M-L, Hoek J, George M, et al. An Exploration of Smoking-to-Vaping Transition Attempts Using a "Smart" Electronic Nicotine Delivery System. *Nicotine Tob Res*. June 2018. doi:10.1093/ntr/nty093

271. Farsalinos KE, Romagna G, Tsiapras D, Kyrzopoulos S, Voudris V. Evaluating Nicotine Levels Selection and Patterns of Electronic Cigarette use in a Group of "Vapers" Who Had Achieved Complete Substitution of Smoking. *Subst Abus Res Treat*. 2013;7:SART.S12756. doi:10.4137/SART.S12756

272. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. *Annu Rev Clin Psychol*. 2008;4:1-32. http://www.ncbi.nlm.nih.gov/pubmed/18509902. Accessed November 1, 2018.

273. Schüz N, Cianchi J, Shiffman S, Ferguson SG. Novel Technologies to Study Smoking Behavior: Current Developments in Ecological Momentary Assessment. *Curr Addict Reports*. 2015;2(1):8-14. doi:10.1007/s40429-015-0039-x

274. Foulds J, Veldheer S, Yingst J, et al. Development of a Questionnaire for Assessing Dependence on Electronic Cigarettes Among a Large Sample of Ex-Smoking E-cigarette Users. *Nicotine Tob Res*. 2015;17(2):186-192. doi:10.1093/ntr/ntu204

275. Morean ME, Krishnan-Sarin S, Sussman S, et al. Development and psychometric validation of a novel measure of sensory expectancies associated with E-cigarette use. *Addict Behav*. August 2018. doi:10.1016/j.addbeh.2018.08.031

276. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. *Biometrics*. 1977;33(1):159. doi:10.2307/2529310

277. van Stralen KJ, Dekker FW, Zoccali C, Jager KJ. Measuring Agreement, More Complicated Than It Seems. *Nephron Clin Pract*. 2012;120(3):c162-c167. doi:10.1159/000337798

278. Bonevski B, Randell M, Paul C, et al. Reaching the hard-to-reach: a systematic review of strategies for improving health and medical research with socially disadvantaged groups. *BMC Med Res Methodol*. 2014;14(1):42. doi:10.1186/1471-2288-14-42

279. Chastin SFM, Dontje ML, Skelton DA, et al. Systematic comparative validation of self-report measures of sedentary time against an objective measure of postural sitting (activPAL). *Int J Behav Nutr Phys Act*. 2018;15(1):1-12. doi:10.1186/s12966-018-0652-x
280. Kosmider L, Cox S, Zaciera M, et al. Daily exposure to formaldehyde and acetaldehyde and potential health risk associated with use of high and low nicotine e-liquid concentrations. *Sci Rep*. 2020;10(1):1-10. doi:10.1038/s41598-020-63292-1
281. Richardson S, McNeill A, Brose LS. Smoking and quitting behaviours by mental health conditions in Great Britain (1993–2014). *Addict Behav*. 2019;90:14-19. doi:10.1016/j.addbeh.2018.10.011
282. Lawrence D, Hafekost J, Hull P, Mitrou F, Zubrick SR. Smoking, mental illness and socioeconomic disadvantage: Analysis of the Australian National survey of mental health and Wellbeing. *BMC Public Health*. 2013;13(1):1-20. doi:10.1186/1471-2458-13-462
283. Ranganathan P, Pramesh C, Aggarwal R. Common pitfalls in statistical analysis: Measures of agreement. *Perspect Clin Res*. 2017;8(4):187-191. doi:10.4103/picr.PICR_123_17
284. ISRCTN registry. ISRCTN - ISRCTN16931827: A trial to assess the benefit of offering an e-cigarette starter kit to smokers attempting to stop smoking with varenicline. http://www.isrctn.com/ISRCTN16931827. Published 2020. Accessed May 30, 2020.
285. Chang P-H, Chiang C-H, Ho W-C, Wu P-Z, Tsai J-S, Guo F-R. Combination therapy of varenicline with nicotine replacement therapy is better than varenicline alone: a systematic review and meta-analysis of randomized controlled trials. *BMC Public Health*. 2015;15(1):689. doi:10.1186/s12889-015-2055-0
286. NHS Digital. *Statistics on NHS Stop Smoking Services in England*.; 2018. www.statisticsauthority.gov.uk/assessment/code-of-practice. Accessed November 15, 2018.
287. Sekhon M, Cartwright M, Francis JJ. Acceptability of healthcare interventions: an overview of reviews and development of a theoretical framework. *BMC Health Serv Res*. 2017;17(1):88. doi:10.1186/s12913-017-2031-8
288. Gould GS, Bar-Zeev Y, Bovill M, et al. Designing an implementation intervention with the Behaviour Change Wheel for health provider smoking

cessation care for Australian Indigenous pregnant women. *Implement Sci*. 2017;12(1):114. doi:10.1186/s13012-017-0645-1

289. Michie S, Whittington C, Hamoudi Z, Zarnani F, Tober G, West R. Identification of behaviour change techniques to reduce excessive alcohol consumption. *Addiction*. 2012;107(8):1431-1440. doi:10.1111/j.1360-0443.2012.03845.x

290. Kock L, Brown J, Shahab L. Association of Socioeconomic Position With e-Cigarette Use Among Individuals Who Quit Smoking in England, 2014 to 2019. *JAMA Netw Open*. 2020;3(6):e204207. doi:10.1001/jamanetworkopen.2020.4207

291. Boland VC, Mattick RP, McRobbie H, Siahpush M, Courtney RJ. "I'm not strong enough; I'm not good enough. i can't do this, I'm failing"- A qualitative study of low-socioeconomic status smokers' experiences with accesssing cessation support and the role for alternative technology-based support. *Int J Equity Health*. 2017;16(1):196. doi:10.1186/s12939-017-0689-5

292. Moore GF, Audrey S, Barker M, et al. Process evaluation of complex interventions: Medical Research Council guidance. *BMJ*. 2015;350:h1258. doi:10.1136/bmj.h1258

293. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006;3(2):77-101. doi:10.1191/1478088706qp063oa

294. Francis JJ, Johnston M, Robertson C, et al. What is an adequate sample size? Operationalising data saturation for theory-based interview studies. *Psychol Health*. 2010;25(10):1229-1245. doi:10.1080/08870440903194015

295. Atkins L, Francis J, Islam R, et al. A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implement Sci*. 2017;12(1):77. doi:10.1186/s13012-017-0605-9

296. Sweeney-Magee M, Kale D, Galton S, Hamill A, Gilbert H. Assessing the fidelity of delivery of an intervention to increase attendance at the English Stop Smoking Services. *Implement Sci*. 2016;11(1):1-11. doi:10.1186/s13012-016-0498-z

297. Chesterman J, Judge K, Bauld L, Ferguson J. How effective are the English smoking treatment services in reaching disadvantaged smokers? *Addiction*. 2005;100:36-45. doi:10.1111/j.1360-0443.2005.01026.x

298. McClure JB, Swan GE, Jack L, et al. Mood, side-effects and smoking outcomes among persons with and without probable lifetime depression taking varenicline. *J Gen Intern Med*. 2009;24(5):563-569. doi:10.1007/s11606-009-0926-8

299. Thirlway F. Nicotine addiction as a moral problem: Barriers to e-cigarette use for smoking cessation in two working-class areas in Northern England. *Soc Sci Med*. 2019;238:112498. doi:10.1016/j.socscimed.2019.112498

300. Hartwell G, Egan M, Petticrew M. Understanding decisions to use e-cigarettes or behavioural support to quit tobacco: a qualitative study of current and ex-smokers and stop smoking service staff. *Addiction*. 2020;115(3):518-526. doi:10.1111/add.14844

301. Rowa-Dewar N, Rooke C, Amos A. Using e-cigarettes in the home to reduce smoking and secondhand smoke: disadvantaged parents' accounts. *Health Educ Res*. 2017;32(1):12-21.

302. Farrimond H. A typology of vaping: Identifying differing beliefs, motivations for use, identity and political interest amongst e-cigarette users. *Int J Drug Policy*. 2017;48:81-90. doi:10.1016/J.DRUGPO.2017.07.011

303. University of East Anglia. UEA researchers evaluate free vape kit scheme - News - UEA. https://www.uea.ac.uk/about/-/uea-researchers-evaluate-free-vape-kit-scheme. Published 2020. Accessed May 30, 2020.

304. Pullicin AJ, Kim H, Brinkman MC, Buehler SS, Clark PI, Lim J. Impacts of Nicotine and Flavoring on the Sensory Perception of E-Cigarette Aerosol. *Nicotine Tob Res*. 2020;22(5):806-813. doi:10.1093/NTR/NTZ058

305. Liu H, Mohammed A, Shanthosh J, et al. Process evaluations of primary care interventions addressing chronic disease: A systematic review. *BMJ Open*. 2019;9(8):e025127. doi:10.1136/bmjopen-2018-025127

306. Craig P, Dieppe P, Macintyre S, Mitchie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: The new Medical Research Council guidance. *BMJ*. 2008;337(7676):979-983. doi:10.1136/bmj.a1655

307. Bellg AJ, Borrelli B, Resnick B, et al. Enhancing Treatment Fidelity in Health Behavior Change Studies: Best Practices and Recommendations From the NIH Behavior Change Consortium. *Heal Psychol*. 2004;23(5):443-451. doi:10.1037/0278-6133.23.5.443

308. Bosworth HB, Granger BB, Mendys P, et al. Medication adherence: A call for action. *Am Heart J*. 2011;162(3):412-424. doi:10.1016/J.AHJ.2011.06.007

309. Hartmann-Boyce J, Begh R, Aveyard P. Electronic cigarettes for smoking cessation. *BMJ*. 2018;360:j5543. doi:10.1136/BMJ.J5543

310. Ziedonis D, Hitsman B, Beckham JC, et al. Tobacco use and cessation in

psychiatric disorders: National Institute of Mental Health report. *Nicotine Tob Res*. 2008;10(12):1691-1715. doi:10.1080/14622200802443569

311. Li J, Fairhurst C, Peckham E, et al. Cost-effectiveness of a specialist smoking cessation package compared with standard smoking cessation services for people with severe mental illness in England: a trial-based economic evaluation from the SCIMITAR+ study. *Addiction*. June 2020:add.15086. doi:10.1111/add.15086
312. Nosek BA, Alter G, Banks GC, et al. Promoting an open research culture. *Science (80-)*. 2015;348(6242):1422-1425. doi:10.1126/science.aab2374
313. Munafò MR. Opening up addiction science. *Addiction*. 2016;111(3):387-388. doi:10.1111/add.13147
314. Kuipers MAG, Beard E, West R, Brown J. Associations between tobacco control mass media campaign expenditure and smoking prevalence and quitting in England: A time series analysis. *Tob Control*. 2018;27(4):455-462. doi:10.1136/tobaccocontrol-2017-053662
315. Michie S, Richardson M, Johnston M, et al. The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions. *Ann Behav Med*. 2013;46(1):81-95. doi:10.1007/s12160-013-9486-6
316. El-Sayed AM, Galea S. *Systems Science and Population Health*. Oxford University Press; 2017.
317. Anderson KM, Odell PM, Wilson PWF, Kannel WB. Cardiovascular disease risk profiles. *Am Heart J*. 1991;121(1):293-298.
318. Borland R, Yong H-H, O'connor RJ, Hyland A, Thompson ME. The reliability and predictive validity of the Heaviness of Smoking Index and its two components: findings from the International Tobacco Control Four Country study. *Nicotine Tob Res*. 2010;12(suppl_1):S45-S50.
319. Action on Smoking and Health. *Local Authority Stop Smoking Support Response to COVID-19*. London; 2020. https://ash.org.uk/wp-content/uploads/2020/05/LA-resposne-to-COVID-19-survey-report.pdf. Accessed June 22, 2020.

Appendices

Appendix 1 - Published version of Chapter 2 (Study 1) in the Lancet Public Health

Articles

Individual-level behavioural smoking cessation interventions tailored for disadvantaged socioeconomic position: a systematic review and meta-regression

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Summary

Background Socioeconomic inequalities in smoking cessation have led to development of interventions that are specifically tailored for smokers from disadvantaged groups. We aimed to assess whether the effectiveness of interventions for disadvantaged groups is moderated by tailoring for socioeconomic position.

Methods For this systematic review and meta-regression, we searched MEDLINE, PsycINFO, Embase, Cochrane Central Register, and Tobacco Addiction Register of Clinical Trials and the IC-SMOKE database from their inception until Aug 18, 2019, for randomised controlled trials of socioeconomic-position-tailored or non-socioeconomic-position-tailored individual-level behavioural interventions for smoking cessation at 6 months or longer of follow-up in disadvantaged groups. Studies measured socioeconomic position via income, eligibility for government financial assistance, occupation, and housing. Studies were excluded if they were delivered at the community or population level, did not report differential effects by socioeconomic position, did not report smoking cessation outcomes from 6 months or longer after the start of the intervention, were delivered at a group level, or provided pharmacotherapy with standard behavioural support compared with behavioural support alone. Individual patient-level data were extracted from published reports and from contacting study authors. Random-effects meta-analyses and mixed-effects meta-regression analyses were done to assess associations between tailoring of the intervention and effectiveness. Meta-analysis outcomes were summarised as risk ratios (RR). Certainty of evidence was assessed within each study using the Cochrane risk-of-bias tool version 2 and the grading of recommendations assessment, development, and evaluation approach. The study is registered with PROSPERO, CRD42018103008.

Findings Of 2376 studies identified by our literature search, 348 full-text articles were retrieved and screened for eligibility. Of these, 42 studies (26 168 participants) were included in the systematic review. 30 (71%) of 42 studies were done in the USA, three (7%) were done in the UK, two (5%) each in the Netherlands and Australia, and one (2%) each in Switzerland, Sweden, Turkey, India, and China. 26 (62%) of 42 studies were trials of socioeconomic-position-tailored interventions and 16 (38%) were non-socioeconomic-position-tailored interventions. 17 (65%) of 26 socioeconomic-position-tailored interventions were in-person or telephone-delivered behavioural interventions, four (15%) were digital interventions, three (12%) involved financial incentives, and two (8%) were brief interventions. Individuals who participated in an intervention, irrespective of tailoring, were significantly more likely to quit smoking than were control participants (RR 1·56, 95% CI 1·39–1·75; I^2=54·5%). Socioeconomic-position-tailored interventions did not yield better outcomes compared with non-socioeconomic-position-tailored interventions for disadvantaged groups (adjusted RR 1·01, 95% CI 0·81–1·27; β=0·011, SE=0·11; p=0·93). We observed similar effect sizes in separate meta-analyses of non-socioeconomic-position-tailored interventions using trial data from participants with high socioeconomic position (RR 2·00, 95% CI 1·36–2·93; I^2=82·7%) and participants with low socioeconomic position (1·94, 1·31–2·86; I^2=76·6%), although certainty of evidence from these studies was graded as low.

Interpretation We found evidence that individual-level interventions can assist disadvantaged smokers with quitting, but there were no large moderating effects of tailoring for disadvantaged smokers. Improvements in tailored intervention development might be necessary to achieve equity-positive smoking cessation outcomes.

Funding Cancer Research UK.

Introduction

In most high-income countries, tobacco smoking prevalence and the associated burden of mortality and disease[1] are greater in groups with lower socioeconomic position.[2] Socioeconomic position refers to the social and economic circumstances that influence how different people are positioned within the structure of society.[3] In England, for example, smoking prevalence is 22·8% among those with manual occupations compared with 12·7% among those with professional to clerical occupations.[4] These

Research in context

Evidence before this study

We searched MEDLINE, PsycINFO, Embase, Cochrane Central Register, and Tobacco Addiction Register of Clinical Trials and the IC-SMOKE project database for studies published in English from database inception until Aug 18, 2019, with the following search terms: smoking cessation or smok* quit* or smok* stop* or smok* cease or smok* cessat* or smok* give up (title and abstract); systematic review or review or RCT or randomi?ed controlled trial or trial or randomi?ed or pragmatic clinical trial (title and abstract); behavio* or behavio?ral support or intervention or counsel* or brief or support or psychol* or individual* or individual-level or behavio?r therapy or cognitive therapy or target* or adapt* or tailor*) not pharma* (title and abstract); and equity or equity impact or inequalit* or poor or disparit* or SES or socio-economic or socio-economic or depriv* or disadvant* social class or occupation or employ or unemploy* or educat* or income or poverty. Tobacco control experts from the authors' institution and others working within the UK Centre for Tobacco and Alcohol Studies were consulted about relevant submitted or in press articles. Several Cochrane reviews focused on individual-level interventions that were not tailored for low socioeconomic position, including motivational interviewing, behavioural support, and different uses of pharmacotherapy. Bauld and colleagues (2010) examined the equity effect of non-socioeconomic-position-tailored interventions. Reviews by Murray and colleagues (2009) and Bryant and colleagues (2011) focused on interventions targeted at disadvantaged smokers. These reviews suggested that, despite behavioural interventions showing promise for reducing inequalities, smoking cessation generally remains lower among disadvantaged groups. However, these reviews did not examine whether socioeconomic position tailoring moderated intervention effectiveness compared with non-socioeconomic-position-tailored approaches.

Added value of this study

To our knowledge, no previous reviews have extended examination of the overall effect of all types of individual-level interventions for smoking cessation in socioeconomically disadvantaged groups to also consider whether socioeconomic position tailoring moderates this effectiveness. We found that both socioeconomic-position-tailored and non-socioeconomic-position-tailored individual-level interventions were effective for smoking cessation in disadvantaged groups. However, there were no large moderating effects of tailoring the interventions for disadvantaged groups compared with not tailoring the interventions. This analysis is an important step forward in gathering evidence about the effectiveness of tailored approaches and encourages further research to improve the effectiveness of equity-focused smoking cessation programmes.

Implications of all the available evidence

This systematic review and meta-regression highlights the challenges in achieving improved long-term smoking cessation in disadvantaged groups through tailoring of interventions. Our results do not imply that socioeconomic-position-tailored approaches should be abandoned, but rather that to improve rates of smoking cessation among disadvantaged smokers new, multifaceted approaches are required at the individual, community, and population level, recognising the wider context of socioeconomically disadvantaged smokers. Further research should assess whether current interventions could be further adapted and improved to extend the benefits into longer-term success over and above the effectiveness of non-socioeconomic-position-tailored approaches.

results are supported by observations according to relative socioeconomic position in other high-income, middle-income, and low-income settings.[3–7]

Regular smoking is established and maintained by a variety of molecular and behavioural factors linked to the rapid release of nicotine from cigarettes.[8,9] Along with other WHO Framework Convention on Tobacco Control measures,[10] individual-level interventions play an important part in disrupting this motivational process[11] to support a successful quitting attempt.[12] However, even with the best support, long-term quitting rates remain low.[13] Interventions that are tailored to smokers from disadvantaged groups stem from the recognition that smokers from disadvantaged groups have greater difficulty in quitting and remaining abstinent[14] than do those from more affluent groups. Behavioural interventions delivered at the individual level that recognise the wider context of socio-economically disadvantaged smokers might prove more successful.[13,15]

The terms socioeconomic position and disadvantaged were operationalised in this Article as populations facing inequalities, marginalisation, or disadvantage in terms of social class, occupation, unemployment, income, poverty, or residential neighbourhood.[16] In many contexts, ethnicity can change the probability of being socioeconomically disadvantaged.[17] Some socio-economic-position-tailored interventions might be delivered to mostly ethnic minority participants—for example, the African American community in the USA. However, given the variety of ethnic distributions and degrees of stigmatisation and the fact that tailoring usually involves some additional cultural adaptation, including such studies was beyond the scope of this Article.

In theory, tailoring interventions to participant characteristics can enhance effectiveness by relating to a participant's life and needs or overcoming specific obstacles to achieve a desired change.[18] In this Article, we assessed interventions according to whether or not they were tailored to socioeconomic position. Socioeconomic-position-tailored interventions are developed specifically for individuals from socioeconomically disadvantaged groups and aim to overcome some of the specific barriers to quitting that smokers from these groups face, such as financial stress, absence of social support, addiction, insufficient self-efficacy, stress, scarce life opportunities, and little interest in and understanding of tobacco harms.[3] By contrast, non-socioeconomic-position-tailored interventions are not designed specifically for disadvantaged groups.[19] In some instances, non-socioeconomic-position-tailored interventions are delivered in a disadvantaged context where recipients have low socioeconomic position, but this does not constitute socioeconomic position tailoring because the intervention has not been developed specifically for such recipients.

Previous reviews have examined the equity effect of non-socioeconomic-position-tailored interventions[20] or focused on interventions targeted towards disadvantaged smokers.[21,22] These reviews suggest that despite behavioural interventions showing promise for reducing inequalities, smoking cessation prevalence generally remains lower among disadvantaged groups.[22,23] A review of research outputs concluded that current research was insufficient to encourage equity-positive improvements in smoking cessation.[24] To our knowledge, no previous reviews have extended examination of the overall effect of all types of individual-level interventions for smoking cessation in socioeconomically disadvantaged groups to also investigate whether socioeconomic position tailoring moderates this effectiveness.

If socioeconomic-position-tailored interventions are not markedly more effective than non-socioeconomic-position-tailored interventions at increasing smoking cessation among smokers with disadvantaged socioeconomic position then these approaches will require redesign. Therefore, we aimed to assess whether the effectiveness of individual-level smoking cessation interventions for disadvantaged groups was moderated by socioeconomic position tailoring.

Methods

Search strategy and selection criteria

This systematic review and meta-regression followed PRISMA guidelines.[25] We searched MEDLINE, PsycINFO, Embase, Cochrane Central Register, and Tobacco Addiction Register of Clinical Trials and the IC-SMOKE database[26] from their inception until Aug 18, 2019, for randomised controlled trials,[27] published in English, of socioeconomic-position-tailored and non-socioeconomic-position-tailored individual-level behavioural interventions for smoking cessation in disadvantaged groups. The following search terms were used: smoking cessation or smok* quit* or smok* stop* or smok* cease or smok* cessat* or smok* give up (title and abstract); RCT or randomi?ed controlled trial or trial or randomi?ed or controlled clinical trial or pragmatic clinical trial (title and abstract); behavio* or behavio?ral support or intervention or counsel* or brief or support or psychol* or individual* or individual-level or behavio?r therapy or cognitive therapy or target* or adapt* or tailor*) not pharma* (title and abstract); and equity or equity impact or inequalit* or under-served or under served or underserved or marginali?ed or poor or affluent or disparit* or SES or socio-economic or socio-economic or depriv* or disadvant* social class or occupation or employ or unemploy* or educat* or income or poverty or neighbo?r* (multiple searches).

This meta-analysis is based on individual participant data. Study authors were contacted if data were not available in a published report. Individual participant-level data were extracted from each study to calculate risk ratios (RRs) and 95% CIs. Studies were excluded if they were delivered at the community or population level, did not report differential effects by socioeconomic position, did not report smoking cessation outcomes from 6 months or longer after the start of the intervention, were delivered at a group level, or provided pharmacotherapy with standard behavioural support compared with behavioural support alone,[28] because pharmacotherapy itself cannot be tailored to socioeconomic position. However, studies in which pharmacotherapy was given to both the intervention and control groups in addition to a behavioural intervention or control or usual care were included.

LK did the literature search. LK and CS independently screened all abstracts. LK screened all full-text articles and CS screened 10% of full-text articles. Inter-rater reliability at abstract screening (Cohen's κ=0·81) and full study screening (Cohen's κ=0·78) were high. Data were extracted by LK. To check reliability, 10% of data extraction was done independently by HT-B. Percentage agreement was more than 98% after comparison (appendix pp 7–8). Conflicts over inclusion and data extraction were resolved through discussion. LK and HT-B independently assessed the risk of bias and certainty of evidence using the Cochrane risk-of-bias tool version 2 and the GRADE approach[29] (appendix pp 2–3). The study protocol is available online.

See Online for appendix

For the study protocol see https://osf.io/2z6cg/

Data analysis

Duplicate papers reporting data from the same trial were identified and the secondary papers were excluded before data extraction. We extracted data on study type and setting, participant characteristics, intervention details, and smoking cessation outcomes (both self-reported and biochemically verified using expired carbon monoxide or salivary cotinine)[30] in a customised data extraction form available online.

Diverse interventions, settings, and participants characterise the field of smoking cessation. We judged it likely that the included studies would show heterogeneity in treatment effect (the observed intervention effects being more different from each other than one would expect because of random error alone). As such, the assumptions of a fixed-effect meta-analysis (that all studies in the meta-analysis share a common overall effect size and that all factors that could influence the effect size are the same across studies),[28] were unlikely to hold. Each study included in this review provides information about a different effect size for smoking cessation. In a random-effects model, the aim is to estimate the mean of a distribution of effects without being overly influenced by any individual study.[32] Therefore, each study is weighted by the inverse of both its within-study and between-study variance (appendix pp 3–4). The SE of the summary effect is calculated as the square root of this variance.

In random-effects meta-analysis models (restricted maximum-likelihood method),[33] we calculated pooled RRs with 95% CIs for both socioeconomic-position-tailored and non-socioeconomic-position-tailored interventions as the weighted average of each individual study's estimated intervention effect. All computations were done on a log scale with the log RR, its variance, and SE, before exponentiating the summary effect for interpretation.

We explored heterogeneity by observation of forest plots and use of the χ^2 test to show whether observed differences in results were compatible with chance alone. We calculated I^2 statistics to examine the level of inconsistency across study findings.[32] I^2 values reflect the degree of overlap of CIs, with lower values indicating that any observed variance is spurious and higher values suggesting that there are real differences in effect size between studies. Publication bias was assessed using funnel plots. Where visual inspection indicated potential funnel plot asymmetry, we did Egger's regression test to investigate this.[28] Our analysis followed an intention-to-treat protocol, whereby participants lost to follow-up were classified as continuing to smoke.

We made the following comparisons using forest plots: individual-level interventions (tailored and not tailored to socioeconomic position) versus passive or active control or usual care; socioeconomic-position-tailored individual-level interventions versus passive or active control or usual care; and non-socioeconomic-position-tailored individual-level interventions (subgroups of low socioeconomic position and high socioeconomic position participants) versus passive or active control or usual care.

A conventional meta-analysis attempts to combine results from studies to elucidate a single summary effect size, but diversity in populations and methods among studies often leads to statistical heterogeneity in the true effects of these studies. Meta-regression acts to extend subgroup analyses and allows, in principle, the effects of multiple factors to be investigated simultaneously. Therefore, in contrast to a meta-analysis, meta-regression aims to relate the size of effect to one or more characteristics of the studies involved. In meta-regression, a pooled effect estimate is predicted based on the values of one or more explanatory study-level variables that might influence the size of the intervention effect.[34] Given a sufficient number of trials (ten studies for each covariate can be sufficient),[34] we used unadjusted and adjusted mixed-effects meta-regression analyses to assess whether variation among studies in smoking cessation effect size was moderated by tailoring of the intervention for disadvantaged groups. The resulting regression coefficient indicates how the outcome variable (log RR for smoking cessation) changes when interventions take a socioeconomic-position-tailored versus non-socioeconomic-tailored approach. A statistically significant ($p<0 \cdot 05$) coefficient indicates that there is a linear association between the effect estimate for smoking cessation and the explanatory variable. More moderators (study-level variables) can be included in the model, which might account for part of the heterogeneity in the true effects. We pre-planned an adjusted model to include important study covariates related to the intensity and delivery of the intervention (number of sessions delivered (above median *vs* below median), whether interventions involved a trained smoking cessation specialist (yes *vs* no), and use of pharmacotherapy in the intervention group (yes *vs* no). These covariates were included a priori as potential confounders given that programmes tailored to socioeconomic position might include more intervention sessions or components or be delivered by different professionals with varying experience. The regression coefficient estimates how the intervention effect in the socioeconomic-position-tailored subgroup differs from the reference group of non-socioeconomic-position-tailored interventions. The true effect for smoking cessation (θi) in the adjusted meta-regression is given by

$$\theta i = \beta_0 + \beta_1 \text{SEP-tailored}_i + \beta_2 \text{SCS}_i + \beta_3 \text{pharmacotherapy}_i + \beta_4 \text{number of sessions}_i + \varepsilon_i + \zeta_i$$

where β are the regression coefficients, SEP is socioeconomic position, SCS is smoking cessation specialist, ε_i is the sampling error through which the effect size of the study deviates from the true effect, and ζ_i indicates that the true effect size of the study is sampled from an overall distribution of effect sizes.

Where a non-significant ($p>0 \cdot 05$) association between socioeconomic position tailoring and intervention effectiveness was found, we used sensitivity analyses using Bayes factors to examine whether the association reflected evidence of no effect, evidence of an effect, or whether the data were insensitive to detection of an effect.[35,36]

We calculated further exploratory unadjusted univariate and adjusted models to explore the extent to which important study characteristics could explain anticipated heterogeneity in the study estimates.

Analyses were done in the RStudio development environment version 1.1.463 using R version 3.5.2 and the metafor package.[37] Calculation of Bayes factors was done with an online calculator. The study is registered with PROSPERO, CRD42018103008.

For the online calculator see http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/Bayes.htm

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Of 2376 studies identified by our literature search, 348 full-text articles were retrieved and screened for eligibility. Of these, 42 studies (26 168 participants) were included in the systematic review (figure 1; table 1). 26 (62%) of 42 studies were trials of socioeconomic-position-tailored interventions and 16 (38) were non-socioeconomic-position-tailored interventions. Measures of socioeconomic position used by studies varied (table 1).

30 (71%) of 42 studies were done in the USA,[illegible] three (7%) were done in the UK,[illegible] two (5%) each in the Netherlands[illegible] and Australia,[illegible] and one (2%) each in Switzerland,[illegible] Sweden,[illegible] Turkey,[illegible] India,[illegible] and China.[illegible]

Ten studies recruited participants during hospital or clinic visits related to general health, cardiac health, dental health, or the health of a participant's child.[illegible] Nine studies recruited only women.[illegible] Three studies exclusively included pregnant women[illegible] and one study recruited only men whose partners were pregnant.[illegible] White participants were the majority in 23 studies[illegible] and African American participants were the majority in 12 studies.[illegible] One study recruited only Chinese participants,[illegible] and another only Indian participants.[illegible]

In-person or telephone support typically included one or more sessions with a health professional who assisted in the quit attempt. These professionals included clinicians, nurses, or health educators, who either provided smoking cessation support as part of their job or worked as a smoking cessation specialist. Digital behavioural support involved interactive and tailored smoking cessation support delivered via text messages, or on a website or page accessible on a computer or other device. Financial incentive condition participants received incentives that were conditional upon them attending support sessions or health visits or contingent upon biochemically validated smoking abstinence at follow-up. Brief interventions consisted of brief advice and assistance related to smoking cessation and outlined general health risks from smoking.

Overall, six (14%) of 42 included studies were classified as being at low risk of bias on all domains considered in the assessment (appendix pp 2–3).

A pooled effect size was estimated based on the 42 studies of socioeconomic-position-tailored and non-socioeconomic-position-tailored individual-level interventions in groups with low socioeconomic position (figure 2). Individuals with low socioeconomic position who participated in an intervention were significantly

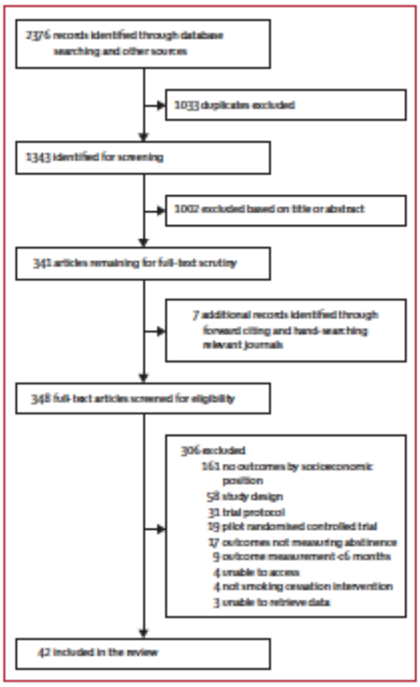

Figure 1: Study selection

more likely to quit smoking than those with low socioeconomic position in control groups (RR 1·56, 95% CI 1·39–1·75). We found evidence of moderate heterogeneity in the effect size between trials (I^2=54·5%). The certainty of evidence for this comparison was deemed to be moderate. A funnel plot suggested that there was no reporting bias for smoking cessation outcomes (appendix p 4).

In an unadjusted univariate model, tailoring of interventions for disadvantaged groups was not associated with smoking cessation effect size (table 2). This absence of association between tailoring of the intervention and intervention effect was also evident in the pre-planned model adjusted for the number of sessions delivered (table 3; model 1), whether interventions were delivered by a smoking cessation specialist and whether the interventions involved the use of pharmacotherapy. However, we found evidence of some intercorrelation among study characteristics in model 1 (table 3), whereby interventions that were delivered by a trained specialist generally involved a greater number of sessions. Therefore, we removed the number of sessions covariate and reran the analyses (table 3; model 2).

	Country	Study design	SEP tailoring	Sample SEP	Women	Mean age, years	Number randomised	Intention to quit	Cigarettes per day, mean (95% CI)	Intervention condition	Control condition	Pharma-cotherapy	Outcome	Follow-up	Bio-chemical verifi-cation	SEP measure
Abroms et al, 2014	USA	Two-group RCT	No	21·9% high school or lower	66%	38	503	No	17·3 (13·9–20·7)	Text message smoking cessation programme	Link to Smokefree.gov website	None	30-day point prevalence	6 months	Yes	Education
Andrews et al, 2016	USA	Two-group RCT	Yes	79·4% <US$20 000 per year	100%	42	200	Yes	12·7 (7·9–17·6)	Face-to-face individual and group support plus NRT	Written materials	NRT	7-day point prevalence	6 months	Yes	Income
Baker et al, 2018	USA	Two-group RCT	No	Medicaid registered	100%	26	1014	Yes	Not reported	High financial incentive plus counselling	Low financial incentive plus counselling	None	7-day point prevalence	6 months post-birth	Yes	Welfare status
Berndt et al, 2017	Netherlands	Three-group RCT	No	41·8% primary and basic vocational	46%	56	625	No	21·1 (17·8–24·4)	Telephone and face-to-face counselling	Usual care	NRT	12-month continued abstinence	12 months	Yes	Education
Bonevski et al, 2018	Australia	Two-group pragmatic RCT	Yes	94% on state benefits	49%	38	431	No	15 (11·5–18·5)	Brief advice and motivational interviewing	On-screen advice to quit, quitline number	NRT	6-month continued abstinence	6 months	Yes	Welfare status
Brooks et al, 2018	USA	Two-group cluster-randomised trial	Yes	Public housing resident	74%	Not reported	331	Yes	Not reported	Motivational interviewing plus NRT offer	Written materials plus brief advice, NRT offer	NRT offered	7-day and 30-day point prevalence	12 months	Yes	Housing tenure
Brown et al, 2014	UK	Two-group RCT	Yes	46·4% long-term unemployed or routine and manual occupation	63%	39	4613	Yes	18·6 (17·5–19·7)	An interactive website intervention	Static website with brief advice	None	6-month continued abstinence	6 months	Yes	Occupation
Choi et al, 2014	USA	Two-group RCT	Yes	61·1% high school or less	20%	42	145	No	21·0 (14·0–28·0)	Website plus telephone support and NRT	Telephone support and NRT	NRT	7-day point prevalence	6 months	Yes	Education
Curry et al, 2003	USA	Two-group RCT	Yes	43·2% <US$10 000 per year	100%	34	303	No	12·1 (8·26–15·9)	Motivational interviewing plus telephone support	Usual care	None	7-day point prevalence	12 months	No	Income
Davis et al, 2014	USA	Two-group RCT	Yes	49·5% high school or less	50%	42	196	Yes	Not reported	Mindfulness training plus NRT	Telephone support plus NRT	NRT	7-day point prevalence	6 months	Yes	Education

(Table 1 continues on next page)

	Country	Study design	SEP tailoring	Sample SEP	Women	Mean age, years	Number randomised	Intention to quit	Cigarettes per day, mean (95% CI)	Intervention condition	Control condition	Pharmacotherapy	Outcome	Follow-up	Biochemical verification	SEP measure
(Continued from previous page)																
Danan et al, 2018[48]	USA	Two-group RCT	No	49·5% high school or less	5%	60	2430	No	≤10–36%, 11–20=42%, ≥21=22%	Proactive outreach with offer of telephone counselling or referral to in-person counselling	Usual care	NRT, bupropion, or varenicline available	6-month continued abstinence	6 months	No	Education
Etter and Schmid, 2016[49]	Switzerland	Two-group RCT	No	18% unemployed	50%	32	805	Yes	16·0 (13·4–18·6)	Written materials, website access, and escalating financial rewards	Written materials plus website access	None	12-month continued abstinence	6 months	Yes	Occupation
Fraser et al, 2017[50]	USA	Two-group RCT	Yes	Medicaid registered	61%	45	1900	No	17·2 (15·5–18·9)	Telephone support plus extra financial incentive	Telephone support plus financial incentive	None	7-day point prevalence	6 months	Yes	Welfare status
Free et al, 2011[51]	UK	Two-group RCT	No	31% manual occupation	45%	37	5800	Yes	Not reported	Text messaging smoking cessation programme	Text messages unrelated to quitting	None	6-month continued abstinence	6 months	Yes	Occupation
Froelicher et al, 2010[52]	USA	Two-group RCT	Yes	58·3% <US$15 000 per year	73%	47	60	No	11·3 (2·5–20·1)	Face-to-face support plus industry and media messaging	Face-to-face support	Unclear	7-day point prevalence	6 months	Yes	Income
Fu et al, 2018[53]	USA	Two-group RCT	Yes	Medicaid registered	71%	Not reported	2406	No	13·6 (12·2–15·0)	Usual care plus proactive telephone and written outreach and NRT	Usual care	NRT	12-month continued abstinence	12 months	No	Welfare status
Glasgow et al, 2000[54]	USA	Two-group RCT	No	42·7% high school or less	100%	24	1154	No	12·0 (10·1–13·9)	Brief behavioural support and clinician advice	Written materials and advice	None	30-day point prevalence	6 months	Yes	Income
Gordon et al, 2010[55]	USA	Two-group RCT	Yes	At or below 200% of US federal poverty level	58%	41	2637	No	Not reported	Brief advice and assistance and NRT	Usual care	NRT	6-month continued abstinence	7·5 months	No	Income
Haas et al, 2015[56]	USA	Two-group RCT	Yes	62·3% medical or medicare recipient	69%	50	707	No	15·0 (12·3–17·7)	Telephone support plus NRT	Usual care	NRT	7-day point prevalence	9 months	No	Welfare status

(Table 1 continues on next page)

	Country	Study design	SEP tailoring	Sample SEP	Women	Mean age, years	Number randomised	Intention to quit	Cigarettes per day, mean (95% CI)	Intervention condition	Control condition	Pharmacotherapy	Outcome	Follow-up	Biochemical verification	SEP measure
(Continued from previous page)																
Yilmaz et al, 2008	Turkey	Three-group RCT	No	50·5% <US$250 per month	100%	Not reported	363	No	6·30 (3·67–8·94)	General health information, child and mother health risks, and booklet	General health information	None	7-day point prevalence	6 months	No	Income
Kendzor et al, 2012	USA	Two-group RCT	No	61·1% unemployed	52%	42	379	No	Not reported	Standard care plus intervention delivered using palmtop computer	Self-help materials plus counselling and NRT	NRT	30-day point prevalence	6 months	Yes	Employment
Lasser et al, 2017	USA	Two-group RCT	No	55% <US$20 000 per year	54%	50	352	Yes	15 (11·1–18·9)	Enhanced usual care (face-to-face support plus written materials and information on local cessation resources)	Usual care (face-to-face support)	NRT offered	7-day point prevalence	12 months	Yes	Income
Lepore et al, 2018	USA	Two-group RCT	Yes	78·7% income below poverty level	84%	33	327	No	11·5 (7·85–15·1)	Face-to-face and telephone support	Nutrition intervention	None	7-day point prevalence	12 months	Yes	Income
Lou et al, 2013	China	Two-group RCT	No	Mean income $US3015 per year	52%	Not reported	3562	No	Not reported	General practioner face-to-face support	Usual care	None	6-month continued abstinence	30 months	Yes	Income
Marks and Sykes, 2002	UK	Two-group RCT	No	37% unemployed	Not reported	Not reported	260	No	Not reported	Enhanced written materials package	Written materials	None	7-day point prevalence	12 months	Yes	Income
McClure et al, 2018	USA	Two-group RCT	Yes	62·6% <US$20 000 per year	62%	44	718	No	19·1 (16·2–22·0)	Telephone support, written materials, and oral health intervention	Telephone support plus written materials	NRT offered	7-day point prevalence	12 months	No	Income
Mundt et al, 2019	USA	Two-group RCT	Yes	Medicaid registered	60%	45	1900	No	17·2 (15·5–18·9)	Financial incentive for taking offered counselling calls	Offer of counselling calls	Offered	7-day point prevalence	6 months	Yes	Welfare status

(Table 1 continues on next page)

	Country	Study design	SEP tailoring	Sample SEP	Women	Mean age, years	Number randomised	Intention to quit	Cigarettes per day, mean (95% CI)	Intervention condition	Control condition	Pharmacotherapy	Outcome	Follow-up	Bio-chemical verification	SEP measure
(Continued from previous page)																
Nohlert et al, 2009[illegible]	Sweden	Two-group RCT	No	23% 0–9 years education	80%	Not reported	300	No	Not reported as mean	Multiple face-to-face support sessions	One face-to-face support session and written materials	None	7-day point prevalence	12 months	No	Education
Okuyemi et al, 2007[illegible]	USA	Two-group cluster-randomised trial	No	Public housing resident	72%	46	174	No	17·5 (11·6–23·4)	Face-to-face and written materials addressing smoking cessation plus NRT	Face-to-face and written materials addressing nutrition	NRT	7-day point prevalence	6 months	Yes	Housing tenure
Pbert et al, 2004[illegible]	USA	Two-group cluster-randomised trial	Yes	46·7% less than high school	100%	26	609	No	16·7 (13·6–19·7)	Face-to-face support and written materials	Usual care	None	7-day point prevalence	6 months post-birth	Yes	Income
Prokhorov et al, 2008[illegible]	USA	Two-group RCT	Yes	Community college students	59%	23	426	No	12·5 (9·2–15·7)	Computer-assisted support and motivational interviewing	Brief face-to-face support and written materials	None	7-day point prevalence	10 months	Yes	Income
Rash et al, 2018[illegible]	USA	Two-group RCT	Yes	Homeless	26%	45	70	Yes	15·4 (6·2–24·6)	Standard care plus financial incentives	Face-to-face counselling	NRT	7-day point prevalence	6 months	Yes	Housing tenure
Ruger et al, 2008[illegible]	USA	Two-group RCT	Yes	Medicaid registered	100%	26	302	No	Not reported	Motivational interviewing and relapse prevention support	Usual care	None	30-day point prevalence	6 months post-birth	Yes	Welfare status
Sarkar et al, 2017[illegible]	India	Two-group cluster-randomised trial	Yes	75·9% <US$70 per month	20%	46	1213	No	Not reported	Brief face-to-face support and breathing exercises	Very brief advice	None	6-month continued abstinence	7 months	Yes	Income
Sheffer et al, 2017[illegible]	USA	Two-group RCT	Yes	56·8% <US$10 000 per year	19%	48	256	Yes	13·8 (9·4–18·2)	Enhanced standard care: SEP-tailored face-to-face cognitive behavioural treatment for tobacco dependence, NRT	Face-to-face cognitive behavioural treatment for tobacco dependence, NRT	NRT	7-day point prevalence	6 months	Yes	SEP (income and education)

(Table 1 continues on next page)

	Country	Study design	SEP tailoring	Sample SEP	Women	Mean age, years	Number randomised	Intention to quit	Cigarettes per day, mean (95% CI)	Intervention condition	Control condition	Pharma-cotherapy	Outcome	Follow-up	Bio-chemical verifi-cation	SEP measure
(Continued from previous page)																
Solomon et al, 2005	USA	Two-group RCT	Yes	Medicaid registered	100%	34	330	Yes	23·6 (18·9–28·3)	Proactive telephone support plus pharma-cotherapy	Pharma-cotherapy	NRT	7-day and 30-day point prevalence	6 months	No	Welfare status
Solomon et al, 2000	USA	Two-group RCT	Yes	Medicaid registered	100%	33	214	Yes	23·7 (17·7–30·0)	Proactive telephone support plus pharma-cotherapy	Pharma-cotherapy	NRT	7-day point prevalence	6 months	Yes	Welfare status
Sorensen et al, 2007	USA	Two-group RCT	Yes	Routine and manual occupation	6%	41	674	No	Not reported	Telephone delivered motivational interviewing, tailored written materials, and NRT	Written materials	NRT offered	7-day point prevalence	6 months	No	Occupation
Stanczyk et al, 2016	Netherlands	Three-group RCT	No	33·6% low education	62%	45	2099	Yes	18·9 (17·2–20·6)	Text and internet-based intervention	General advice	None	12-month continued abstinence	12 months	Yes	Education
Stanton et al, 2004	Australia	Two-group RCT	Yes	Undefined lower SEP (public hospital setting)	0	Not reported	561	No	Not reported	Smoking cessation video plus NRT	Written materials	NRT	Not reported	6 months	Yes	Education or occupation
Strecher et al, 2008	USA	Two-group RCT	No	36·2% high school or less	60%	Not reported	1866	Yes	Not reported	High-depth website intervention plus NRT	Low-depth website intervention plus NRT	NRT	7-day point prevalence	6 months	No	Education
Vidrine et al, 2019	USA	Three-group RCT	No	70% high school or less	51%	49	624	Yes	≤10=30%, 11–20=46%, ≥21=24%	NRT plus text and telephone calls	NRT alone	NRT	30-day point prevalence	6 months	Yes	Education

SEP=socioeconomic position. RCT=randomised controlled trial. NRT=nicotine replacement therapy.

Table 1: Study characteristics

	Intervention	Control: Abstinence (n)	Control: Smoking (n)	Treatment: Abstinence (n)	Treatment: Smoking (n)	Weight (%)	Risk ratio (95% CI)
Abroms et al (2014)	Digital	2	65	3	40	0·4	2·34 (0·41–13·42)
Andrews et al (2016)	Face to face	6	194	17	192	1·3	2·71 (1·09–6·74)
Baker et al (2018)	Incentive	47	462	74	431	3·9	1·59 (1·12–2·24)
Berndt et al (2017)	Face to face	26	104	76	144	3·5	1·73 (1·17–2·55)
Bonevski et al (2018)	Face to face	2	242	1	186	0·2	0·65 (0·06–7·14)
Brooks et al (2018)	Face to face	13	116	20	101	2·1	1·64 (0·85–3·15)
Brown et al (2014)	Digital	64	990	90	998	4·1	1·36 (1·00–1·86)
Choi et al (2014)	Digital	6	72	18	49	1·4	3·49 (1·47–8·29)
Curry et al (2003)	Face to face	8	147	17	139	1·5	2·11 (0·94–4·75)
Davis et al (2014)	Face to face	12	47	23	36	2·3	1·92 (1·05–3·48)
Danan et al (2018)	Telephone	66	602	79	523	4·2	1·33 (0·98–1·81)
Etter and Schmidt (2016)	Incentive	5	157	14	162	1·1	2·58 (0·95–7·00)
Fraser et al (2017)	Incentive	131	821	205	743	5·0	1·57 (1·29–1·92)
Free et al (2011)	Digital	36	838	89	824	3·6	2·37 (1·63–3·45)
Froelicher et al (2010)	Face to face	3	23	3	19	0·6	1·18 (0·26–5·28)
Fu et al (2016)	Telephone	113	824	135	685	4·7	1·37 (1·08–1·72)
Glasgow et al (2000)	Brief	22	556	37	541	2·7	1·68 (1·00–2·81)
Gordon et al (2010)	Brief	22	1133	74	1320	3·0	2·79 (1·74–4·46)
Haas et al (2015)	Telephone	25	308	71	399	3·2	2·01 (1·30–3·10)
Yilmaz et al (2006)	Brief	1	64	19	99	0·3	10·47 (1·43–76·41)
Kendzor et al (2012)	Digital	9	104	4	119	0·9	0·41 (0·13–1·29)
Lasser et al (2017)	Brief	3	93	15	82	0·8	4·95 (1·48–16·55)
Lepore et al (2018)	Telephone	11	153	25	138	2·0	2·29 (1·16–4·49)
Lou et al (2013)	Face to face	3	62	38	54	0·9	8·95 (2·89–27·75)
Marks and Sykes (2002)	Face to face	6	6	23	93	2·0	0·40 (0·20–0·78)
McClure et al (2018)	Telephone	109	251	121	237	4·9	1·12 (0·90–1·38)
Mundt et al (2019)	Incentive	131	821	205	743	5·0	1·57 (1·29–1·92)
Nohlert et al (2009)	Face to face	2	35	4	30	0·5	2·18 (0·43–11·13)
Okuyemi et al (2007)	Face to face	10	97	5	61	1·1	0·81 (0·29–2·27)
Pbert et al (2004)	Face to face	42	236	41	131	3·6	1·58 (1·07–2·32)
Prokhorov et al (2008)	Digital	17	151	26	132	2·4	1·63 (0·92–2·88)
Rash et al (2018)	Incentive	4	29	3	34	0·6	0·67 (0·16–2·77)
Ruger et al (2008)	Face to face	8	92	7	103	1·2	0·80 (0·30–2·11)
Sarkar et al (2017)	Brief	3	599	16	595	0·8	5·25 (1·54–17·94)
Sheffer et al (2017)	Face to face	30	43	29	44	3·5	0·97 (0·65–1·43)
Solomon et al (2005)	Telephone	48	111	65	106	4·2	1·26 (0·93–1·71)
Solomon et al (2000)	Telephone	20	88	24	82	2·7	1·22 (0·72–2·08)
Sorensen et al (2007)	Telephone	7	80	19	82	1·5	2·34 (1·03–5·30)
Stanczyk et al (2016)	Digital	20	229	35	421	2·7	0·96 (0·56–1·62)
Stanton et al (2004)	Digital	25	245	48	243	3·1	1·78 (1·13–2·81)
Strecher et al (2008)	Digital	43	124	71	107	4·1	1·55 (1·13–2·12)
Vidrine et al (2019)	Telephone	13	108	47	268	2·4	1·39 (0·78–2·47)
Overall							1·56 (1·39–1·75)

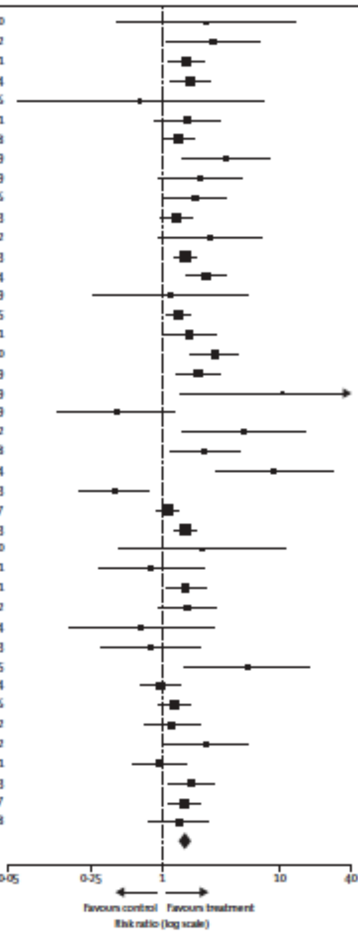

Figure 2: Individual-level interventions compared with control or usual care in socioeconomically disadvantaged groups
Outcome was smoking cessation at ≥6 months follow-up.

Based on an expected RR of 1·5, the calculated Bayes factor for model 2 (0·291) indicated weak evidence that tailoring had no effect on intervention effectiveness. Repeating the calculation based on an expected effect size of 1·1 showed that the data were insensitive to detection of small effects (Bayes factor=0·81).

Exploratory unadjusted univariate models showed no evidence of an association between biochemical verification and smoking cessation effect size, but behavioural support (digital or in-person or telephone), studies with some concerns in at least one domain of the Cochrane risk-of-bias tool for this result, but no high risk

	β (SE)	Risk ratio (95% CI)*	p value	I^2	Adjusted R^2
Tailored for low socioeconomic position†	–0·02 (0·13)	1·02 (0·79–1·32)	0·86	57·02%	0·00%
Trained specialist‡	–0·23 (0·12)	0·79 (0·63–0·99)	0·048	50·38%	13·65%
Pharmacotherapy§	0·27 (0·13)	1·31 (1·01–1·68)	0·045	41·27%	41·20%
Number of sessions¶	–0·01 (0·12)	1·00 (0·78–1·27)	0·99	56·55%	0·00%
Active control‖	–0·03 (0·13)	0·97 (0·75–1·25)	0·80	57·21%	0·00%
Type of support**	–0·26 (0·14)	0·77 (0·58–1·02)	0·064	52·21%	3·48%
Risk of bias††	–0·33 (0·18)	0·72 (0·51–1·02)	0·068	52·66%	5·81%
Biochemical verification‡‡	–0·03 (0·13)	0·97 (0·74–1·26)	0·80	57·39%	0·00%
Intention to quit§§	–0·06 (0·13)	0·94 (0·73–1·20)	0·60	56·28%	0·00%

*Calculated by exponentiating log-transformed estimates of intervention effect. †Socioeconomic-position-tailored vs non-socioeconomic-position-tailored intervention. ‡Intervention involved provider trained in smoking cessation vs not trained in smoking cessation. §Pharmacotherapy delivered vs not delivered. ¶Number of sessions delivered in intervention >4 vs ≤4. ‖Active control vs inactive control. **Digital or face-to-face or telephone intervention vs other intervention (financial incentives and brief interventions). ††High or some concerns over risk of bias vs low risk of bias. ‡‡Biochemically verified smoking cessation vs no biochemically verified smoking cessation. §§Intention to quit vs no intention to quit.

Table 2: Unadjusted univariate associations between intervention factors and effect size of intervention

	β (SE)	Risk ratio* (95% CI)	p value
Model 1			
Tailored for low SEP†	–0·01 (0·12)	1·01 (0·80–1·28)	0·93
Trained specialist‡	–0·28 (0·13)	0·76 (0·58–0·98)	0·0035
Pharmacotherapy§	0·24 (0·14)	1·27 (0·96–1·67)	0·089
Number of sessions¶	0·11 (0·13)	1·12 (0·87–1·45)	0·38
Model 2			
Tailored for low SEP†	0·01 (0·11)	1·01 (0·81–1·27)	0·93
Trained specialist‡	–0·21 (0·11)	0·81 (0·65–0·99)	0·049
Pharmacotherapy§	0·25 (0·13)	1·29 (0·99–1·67)	0·058

SEP=socioeconomic position. *Calculated by exponentiating log-transformed estimates of intervention effect. Associations after mutual adjustment for all variables listed in this table. †SEP-tailored vs non-SEP-tailored intervention. ‡Intervention involved provider trained in smoking cessation vs not trained in smoking cessation. §Pharmacotherapy delivered vs not delivered. ¶Number of sessions delivered in intervention >4 vs ≤4.

Table 3: Adjusted associations between tailoring and effect size of intervention

of bias for any domain, and pharmacotherapy had meaningful associations with effect size (table 2). An adjusted model including these three variables reduced the heterogeneity in the effect size between trials (I^2=16·55%, $R^2_{adjusted}$=82·09%; p=0·0027) compared with the result from the primary meta-analysis (I^2=54·50%; appendix p 5).

We estimated a pooled effect size based on the 26 studies of socioeconomic-position-tailored interventions (appendix p 5). Smokers with disadvantaged socioeconomic position who participated in a socioeconomic-position-tailored intervention were significantly more likely to quit smoking than were those in the control group (RR 1·54, 95% CI 1·37–1·72) with some evidence of heterogeneity in the effect size between trials (I^2=38·10%).

We estimated pooled effect sizes separately for participants with low socioeconomic position and participants with high economic position based on the 12 studies of non-socioeconomic-position-tailored interventions that reported outcomes (figure 3). Four non-socioeconomic-position-tailored interventions were excluded from this comparison as they were delivered in a low socioeconomic position context and did not provide outcome data for participants with high socioeconomic position.

Individuals with low and high socioeconomic position who participated in a non-socioeconomic-position-tailored intervention were significantly more likely to quit smoking than were controls. However, we found evidence of high heterogeneity in the effect size between trials for both the low socioeconomic position and high socioeconomic position subgroups (I^2=76·6% and I^2=82·7%, respectively; figure 3). The results of our subgroup analysis suggest that there were no differences between the estimates of smoking cessation according to the socioeconomic position of participants (appendix pp 5–6).

Funnel plots indicated potential reporting bias due to studies suggesting a beneficial effect being more likely to be published than studies showing no effect (appendix p 6). Egger's test for funnel plot asymmetry showed no difference with respect to the low socioeconomic position participant analysis, but a significant difference for the high socioeconomic position analysis (appendix p 7).

Discussion

We found consistent evidence that individual-level interventions for smoking cessation in socioeconomically disadvantaged groups are effective for smoking cessation. However, we found no evidence that tailoring interventions for smokers with low socioeconomic position significantly moderated effectiveness compared with non-socioeconomic-position-tailored interventions. Bayes factors indicated that there were no large moderating effects, but that the data were insensitive to detection of smaller moderating effects. This finding was not surprising considering that meta-analyses of

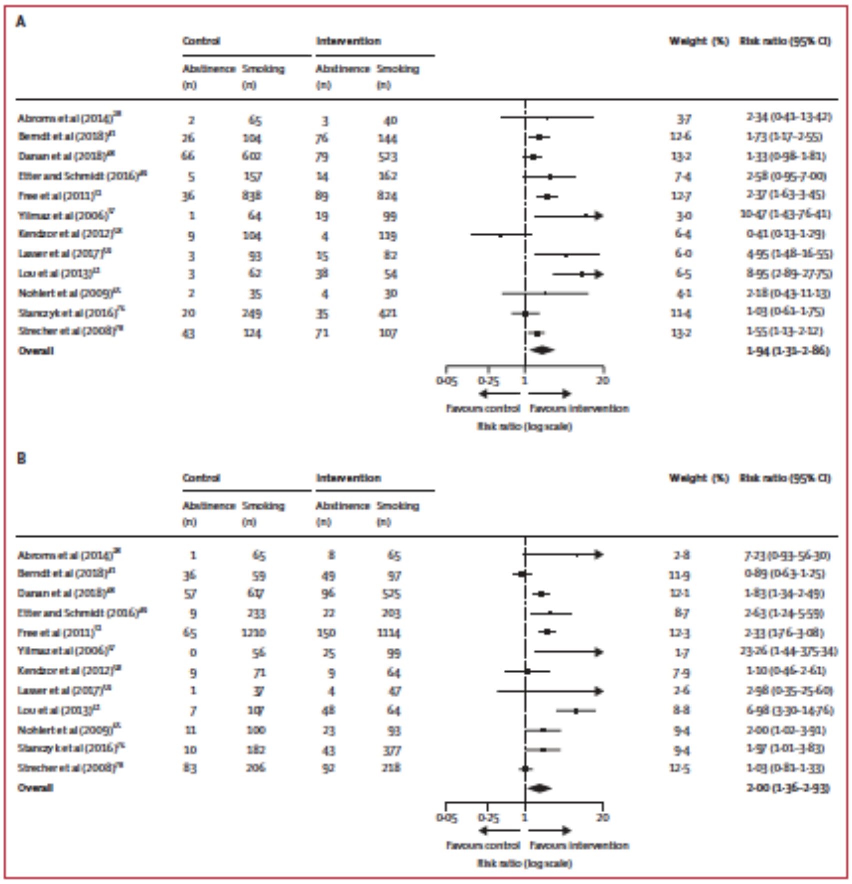

Figure 3: Non-socioeconomic-position-tailored interventions compared with control or usual care in participants with low socioeconomic position (A) and participants with high socioeconomic position (B)

non-socioeconomic-position-tailored interventions showed similar effect sizes for smoking cessation in separate models for participants with high socioeconomic position and with low socioeconomic position from the same study. However, the estimates for subgroups should be interpreted with caution given that overall the evidence from these studies was deemed to be of low certainty.

Tailored individual-level approaches are expected to have an important role in reducing health inequalities by addressing some of the needs specific to disadvantaged smokers. However, our results imply that such tailoring has not yet improved effectiveness compared with non-socioeconomic-position-tailored approaches. Nevertheless, such programmes have shown general effectiveness so should not be withdrawn without replacement.[11,80] To improve the prevalence of smoking cessation among disadvantaged smokers, a new, multifaceted approach is required at the individual, community, and population level. Compared with those with more advantaged socioeconomic position, individuals with low socioeconomic position face more facilitators to smoking uptake and more barriers to quitting,[1] which might outweigh the benefits of tailoring interventions at the individual level.

Comparing results from separate meta-analyses using data from participants with low socioeconomic position and participants with high socioeconomic position from the same trial showed that the effects of non-socio-economic-position-tailored interventions on smoking cessation were similar in all participants. This finding contrasts with a previous review,[illegible] which suggested that non-socioeconomic-position-tailored smoking cessation support interventions were likely to be equity negative (helping participants with advantaged socioeconomic position to quit more than disadvantaged participants). However, this divergence should be interpreted with caution as the inclusion criteria between the studies differed. The current systematic review only included randomised controlled trials of individual-level interventions measuring smoking cessation at least 6 months after baseline. The previous review[illegible] largely focused on face-to-face behavioural support and included observational and correlational designs and randomised controlled trials that involved the use of pharmacotherapy alone. Furthermore, in response to inequalities in access, provision of smoking cessation services in some low-socioeconomic-position areas of the UK has improved, with results from programmes in Scotland indicating improvements in quitting success among disadvantaged smokers.[illegible] These data support the finding from the current review that non-socioeconomic-position-tailored interventions appear to have a similar effectiveness for quitting smoking success across the social gradient, if access to such services is provided.

Nine studies included in this review recruited women only, whereas one study recruited men only. This focus might be a response to the evidence of higher smoking prevalence and health inequalities among disadvantaged ethnic minority women[illegible] and the potential opportunity for a smoking cessation intervention when women are in the clinic either during or following pregnancy.

30 studies in our review used point prevalence (7-day or 30-day) rather than continued abstinence outcomes. Although there is some debate as to which is a more robust measure, a 2010 systematic review[illegible] comparing these two outcome measures concluded that they are highly correlated and produce similar effect sizes for smoking cessation.

This systematic review is not without limitations. Although several covariates were prespecified in the protocol, it was not possible to do the same for all other potentially important covariates and this might result in false-positive conclusions. Therefore, results indicating a reduction in heterogeneity compared with the primary meta-analysis should be viewed as exploratory. Furthermore, study characteristics included in the meta-regression might have been highly correlated, such that an observed association with one study characteristic is in fact reflective of a true association with another correlated characteristic that has not been measured. There was some evidence of clustering of study characteristics, whereby more sessions appeared to take place if a trained specialist was delivering the intervention. It is also possible that the effectiveness of behavioural support depended on the skill of the practitioner delivering it;[illegible] unfortunately a variable to assess practitioner skill was not available for most studies analysed, so meaningful adjustment for this was not possible. However, such effects are generally relatively small[illegible] and so unlikely to have overly biased our results. Furthermore, since we included study quality (which measures bias in trials) in the meta-regression, we argue that we attempted to account for therapist effects as far as possible given the available information. Our risk of bias assessment included deviations from the intended interventions. In cases in which the original study provided no information for this factor, the potential bias was noted and included in the final assessment for overall risk of bias. Other measures of effectiveness for smoking cessation in interventions tailored for disadvantaged groups, such as time to relapse and abstinence at earlier follow-up timepoints, might provide a more nuanced picture of study results.

There are potential limitations related to the operationalisation of socioeconomic position in this Article. Although 39 (93%) of 42 studies were done in high-income countries, there are often between-country differences in terms of how socioeconomic position is experienced and how this influences health behaviour.[1] Furthermore, the socioeconomic position of the underlying sample populations in each study might have differed between socioeconomic-position-tailored and non-socioeconomic-position-tailored interventions. Were this true, the apparent effectiveness of non-socio-economic-position-tailored interventions for smokers with low socioeconomic position discussed in this review might reflect the recruitment of more socioeconomically advantaged participants than in trials of socioeconomic-position-tailored interventions. Trials of non-socio-economic-position-tailored interventions that report outcomes by socioeconomic position might also differ from non-socioeconomic-position-tailored interventions that do not report this. Such studies might focus more on socioeconomic position issues despite not explicitly reporting on tailoring of the intervention to populations with different socioeconomic positions, which might lead to underestimating the moderating effect of socio-economic position tailoring. Therefore, future research in this field should consider using a standardised index of socioeconomic position to allow valid comparison between levels of deprivation across populations.

During the study screening process, it became apparent that relevant studies (n=161) might have been excluded because they did not report their outcomes by socio-economic position, despite potentially having a socio-economically diverse sample of participants. Given the persistent inequalities in smoking rates worldwide, it is becoming ever more important that smoking cessation trials, where possible, collect and report outcomes by socioeconomic position. Studies are typically not powered for robust subgroup analyses by socioeconomic position, but if outcomes are reported in this way then they can be cumulatively included in pooled effect size estimates in future reviews. The certainty of evidence of studies included in this review was rated as moderate for the primary analysis and low for the secondary analyses. As such, it remains possible that the true effects are different to what was estimated.

Despite these limitations, this study has several strengths. To our knowledge, no previous reviews have examined whether socioeconomic position tailoring moderates the effectiveness of individual-level behavioural smoking cessation interventions at 6 months or later in socioeconomically disadvantaged groups. Inclusion of 42 studies in our systematic review made it possible to do a meta-regression analysis, which is a useful tool to extend the analysis and relate the size of treatment effect in clinically and methodologically diverse studies to relevant study characteristics. Considering the growing number of interventions that involve some form of tailoring for disadvantaged groups, this analysis is an important step towards gathering evidence about their effectiveness and might also encourage further equity-focused research that will improve the effectiveness of smoking cessation programmes. Future research in this area should also consider assessing what the most effective components of socioeconomic-position-tailored interventions are by using an appropriate theory-informed taxonomy.[33,34]

This systematic review and meta-regression highlights that although both socioeconomic-position-tailored and non-socioeconomic-position-tailored individual-level interventions for smoking cessation in socioeconomically disadvantaged groups are effective for smoking cessation, based on the evidence available for this review, there is currently no evidence for large moderating effects of tailoring for disadvantaged smokers.

Contributors

LK developed the systematic review with guidance from LS, JB, and RH. LK did all review activities including the study search and data extraction, with assistance from CS during the study screen and HT-B for data extraction (10% independently extracted) and during the risk of bias and certainty of evidence assessment. LK did the meta-analysis and meta-regression. LK wrote the manuscript with contributions from LS, JB, and RH. All authors reviewed the study findings and approved the final version before submission.

Declaration of interests

LS has received honoraria for talks, an unrestricted research grant and travel expenses to attend meetings and workshops by pharmaceutical companies that make smoking cessation products (Pfizer, Johnson & Johnson), has acted as a paid reviewer for grant awarding bodies, and as a paid consultant for health-care companies. JB has received unrestricted research funding to study smoking cessation from Pfizer. All other authors declare no competing interests.

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References

1 WHO. Tobacco. July 26, 2017. http://www.who.int/mediacentre/factsheets/fs339/en/ (accessed Nov 23, 2017).
2 Hiscock R, Bauld L, Amos A, Fidler JA, Munafò M. Socioeconomic status and smoking: a review. *Ann N Y Acad Sci* 2012; 1248: 107–23.
3 Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). *J Epidemiol Community Health* 2006; 60: 7–12.
4 Brown J, West R. Smoking in England. Latest statistics. Smoking Toolkit Study Summary. 2016. http://www.smokinginengland.info/latest-statistics/ (accessed Oct 30, 2019).
5 Greenhalgh E, Bayly M, Winstanley M. Tobacco in Australia: facts and issues. Trends in the prevalence of smoking by socio-economic status. 2017. https://www.tobaccoinaustralia.org.au/chapter-1-prevalence/1-7-trends-in-the-prevalence-of-smoking-by-socioec (accessed June 18, 2018).
6 Jamal A, Phillips E, Gentzke AS, et al. Current cigarette smoking among adults—United States, 2016. *MMWR Morb Mortal Wkly Rep* 2018; 67: 53–59.
7 Bravin JI, Bunge EL, Evare B, Wickham RE, Pérez-Stable EJ, Muñoz RF. Socioeconomic predictors of smoking cessation in a worldwide online smoking cessation trial. *Internet Interv* 2015; 2: 410–18.
8 Benowitz NL. Clinical pharmacology of nicotine: implications for understanding, preventing, and treating tobacco addiction. *Clin Pharmacol Ther* 2008; 83: 531–41.
9 Benowitz NL. Nicotine addiction. *N Engl J Med* 2010; 362: 2295–303.
10 Gravely S, Giovino GA, Craig L, et al. Implementation of key demand-reduction measures of the WHO Framework Convention on Tobacco Control and change in smoking prevalence in 126 countries: an association study. *Lancet Public Health* 2017; 2: e166–74.
11 West R. The multiple facets of cigarette addiction and what they mean for encouraging and helping smokers to stop. *COPD* 2009; 6: 277–83.
12 Aveyard P, Raw M. Improving smoking cessation approaches at the individual level. *Tob Control* 2012; 21: 252–57.
13 Dobbie F, Hiscock R, Leonardi-Bee J, et al. Evaluating Long-term Outcomes of NHS Stop Smoking Services (ELONS): a prospective cohort study. *Health Technol Assess* 2015; 19: 1–156.
14 Kotz D, West R. Explaining the social gradient in smoking cessation: it's not in the trying, but in the succeeding. *Tob Control* 2009; 18: 43–46.
15 Kim K-N, Hong Y-C. The exposome and the future of epidemiology: a vision and prospect. *Environ Health Toxicol* 2017; 32: e2017009.
16 Rutter H, Araújo-Soares V, Brown J, Kelly MP, Michie S, West R. Complex systems and individual-level approaches to population health: a false dichotomy? *Lancet Public Health* 2017; 2: e396–97.
17 Williams DR. Race/ethnicity and socioeconomic status: measurement and methodological issues. *Int J Health Serv* 1996; 26: 483–505.
18 Shahab L, McEwen A. Online support for smoking cessation: a systematic review of the literature. *Addiction* 2009; 104: 1792–804.
19 Graham H, Kelly M. Health inequalities: concepts, frameworks and policy. London: Health Development Agency, 2004.
20 Bauld L, Bell K, McCullough L, Richardson L, Greaves L. The effectiveness of NHS smoking cessation services: a systematic review. *J Public Health (Oxf)* 2010; 32: 71–82.
21 Murray RL, Bauld L, Hackshaw LE, McNeill A. Improving access to smoking cessation services for disadvantaged groups: a systematic review. *J Public Health (Oxf)* 2009; 31: 258–77.
22 Bryant J, Bonevski B, Paul C, McElduff P, Attia J. A systematic review and meta-analysis of the effectiveness of behavioural smoking cessation interventions in selected disadvantaged groups. *Addiction* 2011; 106: 1568–85.
23 Hiscock R, Murray S, Brose LS, et al. Behavioural therapy for smoking cessation: the effectiveness of different intervention types for disadvantaged and affluent smokers. *Addict Behav* 2013; 38: 2787–96.

24 Courtney RJ, Naicker S, Shakeshaft A, Clare P, Martire KA, Mattick RP. Smoking cessation among low-socioeconomic status and disadvantaged population groups: a systematic review of research output. *Int J Environ Res Public Health* 2015; 12: 6403–22.

25 Andrews JO, Mueller M, Newman SD, et al. The association of individual and neighborhood social cohesion, stressors, and crime on smoking status among African-American women in southeastern US subsidized housing neighborhoods. *J Urban Health* 2014; 91: 1158–74.

26 de Bruin M, Viechtbauer W, Eisma MC, et al. Identifying effective behavioural components of Intervention and Comparison group support provided in SMOKing cEssation (IC-SMOKE) interventions: a systematic review protocol. *Syst Rev* 2016; 5: 77.

27 Cochrane EPOC. What study designs should be included in an EPOC review and what should they be called? 2017. https://epoc.cochrane.org/sites/epoc.cochrane.org/files/public/uploads/EPOC%20Study%20Designs%20About.pdf (accessed Aug 21, 2019).

28 Hartmann-Boyce J, Chepkin SC, Ye W, Bullen C, Lancaster T. Nicotine replacement therapy versus control for smoking cessation. *Cochrane Database Syst Rev* 2018; 5: CD000146.

29 Schünemann H, Brożek J, Oxman GGA. Handbook for grading the quality of evidence and the strength of recommendations using the GRADE approach. October, 2013. https://gdt.gradepro.org/app/handbook/handbook.html (accessed Oct 30, 2019).

30 Benowitz NL, III PJ, Ahijevych K, et al. Biochemical verification of tobacco use and cessation. *Nicotine Tob Res* 2002; 4: 149–59.

31 Chen D-G, Peace KE. Applied meta-analysis with R. Boca Raton, FL: Chapman and Hall/CRC Press, 2013.

32 Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. Introduction to meta-analysis. Hoboken, NJ: Wiley, 2009.

33 Langan D, Higgins JPT, Jackson D, et al. A comparison of heterogeneity variance estimators in simulated random-effects meta-analyses. *Res Synth Methods* 2019; 10: 83–98.

34 Borenstein M, Hedges L, Higgins J, Rothstein H. Meta-regression. Introduction to meta-analysis. Chichester: John Wiley and Sons, 2009: 187–203.

35 West R. Using Bayesian analysis for hypothesis testing in addiction science. *Addiction* 2016; 111: 3–4.

36 Dienes Z. Using Bayes to get the most out of non-significant results. *Front Psychol* 2014; 5: 781.

37 Viechtbauer W. Conducting meta-analyses in R with the metafor package. *J Stat Softw* 2010; 36: 1–48.

38 Abroms LC, Boal AL, Simmens SJ, Mendel JA, Windsor RA. A randomized trial of Text2Quit: a text messaging program for smoking cessation. *Am J Prev Med* 2014; 47: 242–50.

39 Andrews JO, Mueller M, Dooley M, Newman SD, Magwood GS, Tingen MS. Effect of a smoking cessation intervention for women in subsidized neighborhoods: a randomized controlled trial. *Prev Med* 2016; 90: 170–76.

40 Baker TB, Fraser DL, Kobinsky K, et al. A randomized controlled trial of financial incentives to low income pregnant women to engage in smoking cessation treatment: effects on post-birth abstinence. *J Consult Clin Psychol* 2018; 86: 464–73.

41 Berndt N, de Vries H, Lechner L, et al. High intensity smoking cessation interventions: cardiac patients of low socioeconomic status and low intention to quit profit most. *Neth Heart J* 2017; 25: 24–32.

42 Bonevski B, Twyman L, Paul C, et al. Smoking cessation intervention delivered by social service organisations for a diverse population of Australian disadvantaged smokers: a pragmatic randomised controlled trial. *Prev Med* 2018; 112: 38–44.

43 Brooks DR, Burtner JL, Borrelli B, et al. Twelve-month outcomes of a group-randomized community health advocate-led smoking cessation intervention in public housing. *Nicotine Tob Res* 2018; 20: 1434–41.

44 Brown J, Michie S, Geraghty AW, et al. Internet-based intervention for smoking cessation (StopAdvisor) in people with low and high socioeconomic status: a randomised controlled trial. *Lancet Respir Med* 2014; 2: 997–1006.

45 Choi SH, Waltje AH, Ronis DL, et al. Web-enhanced tobacco tactics with telephone support versus 1-800-QUIT-NOW telephone line intervention for operating engineers: randomized controlled trial. *J Med Internet Res* 2014; 16: e255.

46 Curry SJ, Ludman EJ, Graham E, Stout J, Grothaus L, Lozano P. Pediatric-based smoking cessation intervention for low-income women: a randomized trial. *Arch Pediatr Adolesc Med* 2003; 157: 295–302.

47 Davis JM, Manley AR, Goldberg SB, Smith SS, Jorenby DE. Randomized trial comparing mindfulness training for smokers to a matched control. *J Subst Abuse Treat* 2014; 47: 213–21.

48 Danan ER, Fu SS, Clothier BA, et al. The equity impact of proactive outreach to smokers: analysis of a randomized trial. *Am J Prev Med* 2018; 55: 506–16.

49 Etter J-F, Schmid F. Effects of large financial incentives for long-term smoking cessation: a randomized trial. *J Am Coll Cardiol* 2016; 68: 777–85.

50 Fraser DL, Fiore MC, Kobinsky K, et al. A randomized trial of incentives for smoking treatment in Medicaid members. *Am J Prev Med* 2017; 53: 754–63.

51 Free C, Knight R, Robertson S, et al. Smoking cessation support delivered via mobile phone text messaging (txt2stop): a single-blind, randomised trial. *Lancet* 2011; 378: 49–55.

52 Froelicher ES, Doolan D, Yerger VB, McGruder CO, Malone RE. Combining community participatory research with a randomized clinical trial: the Protecting the Hood Against Tobacco (PHAT) smoking cessation study. *Heart Lung* 2010; 39: 50–63.

53 Fu SS, van Ryn M, Nelson D, et al. Proactive tobacco treatment offering free nicotine replacement therapy and telephone counselling for socioeconomically disadvantaged smokers: a randomised clinical trial. *Thorax* 2016; 71: 446–53.

54 Glasgow RE, Whitlock EP, Eakin EG, Lichtenstein E. A brief smoking cessation intervention for women in low-income planned parenthood clinics. *Am J Public Health* 2000; 90: 786–89.

55 Gordon JS, Andrews JA, Albert DA, Crews KM, Payne TJ, Severson HH. Tobacco cessation via public dental clinics: results of a randomized trial. *Am J Public Health* 2010; 100: 1307–12.

56 Haas JS, Linder JA, Park ER, et al. Proactive tobacco cessation outreach to smokers of low socioeconomic status: a randomized clinical trial. *JAMA Intern Med* 2015; 175: 218–26.

57 Yilmaz G, Karacan C, Yoney A, Yilmaz T. Brief intervention on maternal smoking: a randomized controlled trial. *Child Care Health Dev* 2006; 32: 73–79.

58 Kendzor DE, Reitzel LR, Mazas CA, et al. Individual- and area-level unemployment influence smoking cessation among African Americans participating in a randomized clinical trial. *Soc Sci Med* 2012; 74: 1394–401.

59 Lasser KE, Quintiliani LM, Truong V, et al. Effect of patient navigation and financial incentives on smoking cessation among primary care patients at an urban safety-net hospital: a randomized clinical trial. *JAMA Intern Med* 2017; 177: 1798–807.

60 Lepore SJ, Collins BN, Coffman DL, et al. Kids safe and smokefree (KISS) multilevel intervention to reduce child tobacco smoke exposure: long-term results of a randomized controlled trial. *Int J Environ Res Public Health* 2018; 15: 1239.

61 Lou P, Zhu Y, Chen P, et al. Supporting smoking cessation in chronic obstructive pulmonary disease with behavioral intervention: a randomized controlled trial. *BMC Fam Pract* 2013; 14: 91.

62 Marks DF, Sykes CM. Randomized controlled trial of cognitive behavioural therapy for smokers living in a deprived area of London: outcome at one-year follow-up. *Psychol Health Med* 2002; 7: 17–24.

63 McClure JB, Bush T, Anderson ML, et al. Oral health promotion and smoking cessation program delivered via tobacco quitlines: the Oral Health 4 Life Trial. *Am J Public Health* 2018; 108: 689–95.

64 Mundt MP, Baker TB, Fraser DL, Smith SS, Piper ME, Fiore MC. Paying low-income smokers to quit? The cost-effectiveness of incentivizing tobacco quit line engagement for Medicaid recipients who smoke. *Value Health* 2019; 22: 177–84.

65 Nohlert E, Tegelberg Å, Tillgren P, Johansson P, Rosenblad A, Helgason ÁR. Comparison of a high and a low intensity smoking cessation intervention in a dentistry setting in Sweden—a randomized trial. *BMC Public Health* 2009; 9: 121.

66 Okuyemi KS, James AS, Mayo MS, et al. Pathways to health: a cluster randomized trial of nicotine gum and motivational interviewing for smoking cessation in low-income housing. *Health Educ Behav* 2007; 34: 43–54.

67 Pbert L, Ockene JK, Zapka J, et al. A community health center smoking-cessation intervention for pregnant and postpartum women. *Am J Prev Med* 2004; 26: 377–85.

68 Prokhorov AV, Yost T, Mullin-Jones M, et al. "Look at your health": outcomes associated with a computer-assisted smoking cessation counseling intervention for community college students. *Addict Behav* 2008; 33: 757–71.

69 Rash CJ, Petry NM, Alessi SM. A randomized trial of contingency management for smoking cessation in the homeless. *Psychol Addict Behav* 2018; 32: 141–48.

70 Ruger JP, Weinstein MC, Hammond SK, Kearney MH, Emmons KM. Cost-effectiveness of motivational interviewing for smoking cessation and relapse prevention among low-income pregnant women: a randomized controlled trial. *Value Health* 2008; 11: 191–98.

71 Sarkar BK, West R, Arora M, Ahluwalia JS, Reddy KS, Shahab L. Effectiveness of a brief community outreach tobacco cessation intervention in India: a cluster-randomised controlled trial (the BABEX Trial). *Thorax* 2017; 72: 167–73.

72 Sheffer CE, Bickel WK, Franck CT, et al. Improving tobacco dependence treatment outcomes for smokers of lower socioeconomic status: a randomized clinical trial. *Drug Alcohol Depend* 2017; 181: 177–85.

73 Solomon LJ, Marcy TW, Howe KD, Skelly JM, Reinier K, Flynn BS. Does extended proactive telephone support increase smoking cessation among low-income women using nicotine patches? *Prev Med* 2005; 40: 306–13.

74 Solomon LJ, Scharoun GM, Flynn BS, Secker-Walker RH, Sepinwall D. Free nicotine patches plus proactive telephone peer support to help low-income women stop smoking. *Prev Med* 2000; 31: 68–74.

75 Sorensen G, Barbeau EM, Stoddard AM, et al. Tools for health: the efficacy of a tailored intervention targeted for construction laborers. *Cancer Causes Control* 2007; 18: 51–59.

76 Stanczyk NE, de Vries H, Candel MJJM, Muris JWM, Bolman CAW. Effectiveness of video- versus text-based computer-tailored smoking cessation interventions among smokers after one year. *Prev Med* 2016; 82: 42–50.

77 Stanton W R, Lowe JB, Moffatt J, Del Mar CB. Randomised control trial of a smoking cessation intervention directed at men whose partners are pregnant. *Prev Med* 2004; 38: 6–9.

78 Strecher VJ, McClure JB, Alexander GL, et al. Web-based smoking-cessation programs: results of a randomized trial. *Am J Prev Med* 2008; 34: 373–81.

79 Vidrine DJ, Frank-Pearce SG, Vidrine JI, et al. Efficacy of mobile phone-delivered smoking cessation interventions for socioeconomically disadvantaged individuals: a randomized clinical trial. *JAMA Intern Med* 2019; 179: 167–74.

80 Smith C, Hill S, Amos A. Stop smoking inequalities: a systematic review of socioeconomic inequalities in experiences of smoking cessation interventions in the UK. July, 2018. https://www.cancerresearchuk.org/sites/default/files/stop_smoking_inequalities_2018.pdf. (accessed Sept 3, 2018).

81 Hill S, Amos A, Clifford D, Platt S. Impact of tobacco control interventions on socioeconomic inequalities in smoking: review of the evidence. *Tob Control* 2014; 23: e89–97.

82 Hughes JR, Carpenter MJ, Naud S. Do point prevalence and prolonged abstinence measures produce similar results in smoking cessation studies? A systematic review. *Nicotine Tob Res* 2010; 12: 756–62.

83 Walters SJ. Therapist effects in randomised controlled trials: what to do about them. *J Clin Nurs* 2010; 19: 1102–12.

84 Michie S, Richardson M, Johnston M, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med* 2013; 46: 81–95.

Appendix 3 - Published version of Chapter 4 (Study 3) in JAMA Network Open

JAMA Network Open

Original Investigation | Substance Use and Addiction

Association of Socioeconomic Position With e-Cigarette Use Among Individuals Who Quit Smoking in England, 2014 to 2019

Loren Kock, MSc; Jamie Brown, PhD; Lion Shahab, PhD

Abstract

IMPORTANCE e-Cigarette use among individuals who quit smoking more than 1 ago in England is highest among those with lower socioeconomic position and may affect smoking-related health inequalities, depending on whether the devices protect against relapse to tobacco smoking.

OBJECTIVES To assess trends in current e-cigarette use by socioeconomic position among individuals who have quit smoking for at least 1 year, to capture postcessation initiation among those who quit within the past year and did not use an e-cigarette in their most recent quit attempt (representing recent initiation), and to capture postcessation initiation among those who quit smoking before e-cigarettes became popular in 2011 (representing late initiation).

DESIGN, SETTING, AND PARTICIPANTS This cross-sectional study of 34 442 adults (≥16 years) who formerly smoked used data from the Smoking Toolkit Study (conducted 2014-2019), a nationally representative, monthly, repeated, cross-sectional, household survey of smoking and smoking cessation in England. Data analysis was conducted in December 2019.

EXPOSURES Socioeconomic position based on occupation.

MAIN OUTCOMES AND MEASURES Current self-reported e-cigarette use.

RESULTS Weighted samples consisted of 19 297 individuals who had quit smoking for at least 1 year (mean [SD] age, 59.2 [17.0] years; 9024 [46.8%] women), 904 who quit in the past year and did not use an e-cigarette in their most recent quit attempt (mean [SD] age, 41.6 [17.1] years; 445 [49.3%] women), and 14 241 who quit before 2011 (mean [SD] age, 63.6 [14.6] years; 6619 [46.5%] women). Among those who had quit smoking fot at least 1 year, e-cigarette use increased from 3.3% (95% CI, 2.7%-4.0%) in 2014 to 10.4% (95% CI, 9.2%-11.6%) in 2019 among all socioeconomic groups. Use was more common among those with lower socioeconomic position than those with higher socioeconomic position (odds ratio, 1.59; 95% CI, 1.05-2.40; *P* = .03). Regarding postcessation initiation of e-cigarettes, among those who quit smoking in the past year and did not use an e-cigarette in their most recent quit attempt, 7.1% (95% CI, 5.9%-9.3%) initiated e-cigarette use after smoking cessation, and there was no clear trend over time or any difference according to socioeconomic position. Among those who quit before 2011, there was an overall increase in use of e-cigarettes (0.8% [95% CI, 0.5%-1.2%] in 2014 to 2.1% [95% CI, 1.4%-2.8%] in 2019), but there were no apparent differences in use across socioeconomic position.

CONCLUSIONS AND RELEVANCE In this study, e-cigarette use increased among all participants from 2014 to 2019 but was highest among those with lower socioeconomic position. Continued monitoring of this socioeconomic patterning is important because if e-cigarettes do not confer the public health benefit of protection against relapse to smoking, then equity-negative disadvantages of long-term usage are more likely. Late, but not recent, postcessation initiation of e-cigarettes has

(continued)

Key Points

Question Is socioeconomic position associated with use of e-cigarettes among those who formerly smoked, and has use e-cigarette use changed over time?

Findings In this cross-sectional study of 34 442 individuals who formerly smoked, e-cigarette use increased among all who had not smoked for at least 1 year but was highest among those with lower socioeconomic position. Among those who quit smoking before 2011, there was no evidence for an association between socioeconomic position and e-cigarette use.

Meaning In this study, lower socioeconomic position was associated with higher rates of e-cigarette use among those who quit smoking after e-cigarettes became widely available, likely reflecting continued use of e-cigarettes as a long-term cessation aid among individuals with lower socioeconomic positions.

\+ Editorial

\+ Supplemental content

Author affiliations and article information are listed at the end of this article.

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Abstract (continued)

increased over time but is not likely to affect smoking-related health inequalities because there were no differences by socioeconomic position.

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Introduction

In most high-income countries, smoking rates are highest among groups with socioeconomic disadvantage.[1] Considering the high rates of mortality and morbidity that smoking causes, reducing these inequalities remains an important priority.

e-Cigarettes are the most popular support for quitting smoking in England,[2] with increasing evidence for the devices as an effective method for smoking cessation.[3,4] They are generally thought to confer substantially lower levels of harm to users compared with combusted tobacco.[5-8] Until evidence emerges regarding the devices' protection against relapse to smoking in the longer term, it is important to monitor the increasing number of individuals who formerly smoked[9] and now use e-cigarettes[2] because without the benefit of protecting against relapse to smoking, their long-term use is likely to be harmful.

There are several possible trajectories of use among individuals who formerly smoked. Users may initiate e-cigarette use before or during a quit attempt and continue to use them in the long term once they have quit.[4,10] Alternatively, as will be assessed in this study, e-cigarette initiation may occur among individuals who formerly smoked but did not use an e-cigarette in their quit attempt. This initiation may occur within a year of quitting or in the longer term.

US research using National Health Interview Survey data indicated that individuals with higher education were more likely to transition from smoking to exclusive e-cigarette use compared with individuals with less educational attainment.[11] Also in the US, recent Population Assessment of Tobacco and Health Study data have shown that exclusive e-cigarette use was more likely among higher-income smokers.[12] These findings contrast with the current evidence on e-cigarette use in the UK. In England specifically, there are no apparent differences in e-cigarette use during a quit attempt between smokers by socioeconomic position, but a social gradient in use by those who quit smoking for at least 1 year exists, such that there appears to be greater use among groups with lower socioeconomic position.[13,14] Therefore, it is likely that individuals who formerly smoked with higher socioeconomic position are using e-cigarettes during a quit attempt before discontinuing their use. In contrast, a greater proportion of individuals who formerly smoked with lower socioeconomic position may continue to use e-cigarettes after their smoking quit attempt or to initiate e-cigarettes after smoking cessation. However, these potential socioeconomic position trajectories have not been examined in detail. Individuals who smoke and have socioeconomic disadvantage are thought to be more dependent on nicotine because of generally initiating smoking at a younger age and smoking more cigarettes per day.[15] Such dependence might encourage greater use of e-cigarettes after quitting for pleasure, to satisfy cravings, and potentially to prevent relapse to smoking.[16,17]

e-Cigarettes have been on the UK market for approximately a decade, allowing for an examination of the trends in use among individuals who formerly smoked and are using the devices. Using data from the Smoking Toolkit Study (2014-2019), this study's aims were to assess trends in e-cigarette use according to socioeconomic position by examining current use of e-cigarettes among all individuals who had quit smoking for at least 1 year and recent and late initiation of e-cigarettes after smoking cessation, respectively, among those who quit smoking in the past year but did not use an e-cigarette in their quit attempt (recent initiation) and those quit smoking before e-cigarettes became popular in 2011 (late initiation). To contextualize observed trends of e-cigarette use against another widely available nicotine delivery product, this study also assessed trends in the use of nicotine replacement therapy by socioeconomic position in the same categories listed earlier.

Methods

Study Design

This study followed a repeated cross-sectional survey design. Smoking Toolkit Study data collected from January 2014 to September 2019 were used. We selected 2014 as the referent year because it was the first year in which the Smoking Toolkit Study measured e-cigarette use among all respondents.

The analytic sample consisted of adults aged 16 years and older living in households in England. The Smoking Toolkit Study involves monthly cross-sectional household interviews of 1700 to 1800 adults, conducted by the market research specialist Ipsos MORI. Sampling of participants for the baseline survey uses a hybrid of random probability and simple quota sampling. This involves assorting England into more than 170 000 initial output areas made up of approximately 300 households, stratified by the 9 regions of England. Interviews are then conducted with a single member of households within randomly assigned stratified output areas. This continues in each area until quotas based on area demographic characteristics are fulfilled. Given the high number of output areas included in each wave, which are themselves randomly sampled from more than 170 000 initial output areas, it is unlikely that there are substantial clusters resulting in bias. All cases were weighted with the rim (marginal) weighting technique to match the English population profile relevant to the time each monthly survey was collected.[18]

The Smoking Toolkit Study was approved by University College London's research ethics committee, and participants provided full written informed consent. The data are anonymized when received by University College London. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline were used in the design and reporting of this study.[19]

Measures

Main Outcomes

e-Cigarette and Nicotine Replacement Therapy Use Among Individuals Who Quit Smoking For at Least 1 Year | Responses to the question "smoking status?" were used to identify those who had quit smoking for at least 1 year. Responses to the question, "Can I check whether you are using any of the following?" were used to identify the nicotine product being used. Answer selections of e-cigarette and nicotine replacement therapy (which included nicotine patch, nicotine gum, nicotine lozenges or tablets, nicotine inhaler, and nicotine nasal spray) in response to the question were used as the outcome measures for e-cigarette and nicotine replacement therapy usage, respectively, among respondents.

Recent Initiation of e-Cigarette or Nicotine Replacement Therapy Among Those Who Quit Smoking in the Past Year But Did Not Use These Products in Their Most Recent Quit Attempt | Responses to the question "What did you use to help stop smoking during the most recent serious quit attempt?" were used to identify those who quit smoking in the past year and used either an e-cigarette or nicotine replacement therapy in their quit attempt. Answer selection of e-cigarette or any form of nicotine replacement therapy indicated respective product use and triggered exclusion of such participants from the subsequent analysis. Current e-cigarette or nicotine replacement therapy use was then ascertained with answers of e-cigarette and nicotine replacement therapy, respectively, in response to the question "Can I check whether you are using any of the following?" Therefore, the remaining sample included those who quit smoking within the past year and who started using an e-cigarette or nicotine replacement therapy only after they had quit smoking. Prevalence of use of e-cigarettes and nicotine replacement therapy among this group was calculated by counting the number of respondents who endorsed use of either product to the previously mentioned question outside of a quit attempt, divided by the number of individuals who reported quitting without assistance from the respective products.

Late Initiation of e-Cigarettes Among Individuals Who Quit Smoking Before 2011 | As a measure of late initiation of e-cigarette use, we assessed current e-cigarette use among those who had quit before e-cigarettes became popular in 2011 (ie, >8 years ago). Length of abstinence (how many years ago a respondent quit smoking) was calculated as actual age minus the age when the respondent stopped smoking.

To create subgroups of respondents for each year from 2014 to 2019 who had quit smoking before 2011, the length of abstinence calculated as mentioned earlier was used as follows: 2014, respondents with length of abstinence at least 4 years; 2015, those with length of abstinence at least 5 years; 2016, those with length of abstinence at least 6 years; 2017, those with length of abstinence at least 7 years; 2018, those with length of abstinence at least 8 years; and 2019, those with length of abstinence at least 9 years. Current e-cigarette use was ascertained as described earlier in response to the question, "Can I check whether you are using any of the following?" Answer selections of electronic cigarette in response to the question were used as the outcome measures for e-cigarette usage. Prevalence of e-cigarette use among this group was calculated by counting the number of respondents who endorsed use of e-cigarettes, divided by the total number of individuals who quit smoking before 2011.

Socioeconomic Variables

Smoking Toolkit Study respondents were stratified according to socioeconomic position with the National Readership Survey classification system for social grade based on occupation.[20] This measure typically contains 5 categories (ie, AB, C1, C2, D, and E) but was collapsed to 2 groups with higher and intermediate managerial, administrative and professional, supervisory, clerical, and junior managerial occupations operationalized as a proxy for higher socioeconomic position; and semiskilled and unskilled manual workers, state pensioners, casual and lowest-grade workers, and unemployed with state benefits only operationalized as a proxy for lower socioeconomic position.

Living in social housing has been reported to be an independent risk factor for smoking in England.[21] Therefore, sensitivity analyses were conducted with housing tenure[22] as an alternative measure of socioeconomic position. This measure was collapsed to 2 groups, social housing (local authority or housing association) and other (mortgage bought, owned outright, private renting, and other).

Covariates

Adjusting e-Cigarette and Nicotine Replacement Therapy Use for Background Popularity of Each Respective Product

Prevalence of e-cigarettes and nicotine replacement therapy use was adjusted for background popularity of each product in the general population. We replaced the denominator for each subgroup with the general population denominator and expressed the prevalence as a percentage of use in the general population.

Sociodemographic Characteristics

The sociodemographic characteristics sex (categorized as women or other) and age (categories 16-24, 25-34, 35-44, 45-54, 55-64, and ≥65 years) were measured. We also measured region in England (London, North East, North West, Yorkshire and Humber, East Midlands, West Midlands, East of England, South East, and South West).

Statistical Analysis

To assess trends in the associations between e-cigarette or nicotine replacement therapy use and year among ex-smokers, we constructed multivariable logistic regression models including survey year (categoric predictor variable with referent year 2014) and socioeconomic position (2 categories with the following referent: higher and intermediate managerial, administrative and professional, supervisory, clerical, and junior managerial occupations) and the interaction terms. All models were adjusted for age, sex, and region. Data analysis was carried out in R version 3.5.2 (R Project for Statistical Computing) in December 2019. A 2-sided $P < .05$ was considered statistically significant. The analysis plan was preregistered on the Open Science Framework. Participants with missing data for any of the variables in the analyses were excluded.

All associations are reported stratified by year. Odds ratios (ORs) with 95% CIs (adjusted for age, sex, and region) indicate the associations between e-cigarette use and year or socioeconomic position. The inclusion of the socioeconomic position–by-year interaction terms allowed us to examine any differential time trends according to socioeconomic position.

Sensitivity analyses were run with housing tenure as an alternative measure of socioeconomic position. Results on prevalence of use for the groups described earlier were also plotted with adjustment for background popularity in the general population.

Quasi-complete separation occurred in the yearly stratified models involving individuals who quit smoking in the last year. To resolve this, the following covariates were merged to become dichotomous predictors (age, 16-44 vs ≥45 years; region, south vs north).

Results

A weighted total of 19 297 individuals who quit smoking for more than 1 year (mean [SD] age, 59.2 [17.0] years; 9024 [46.8%] women), 904 who quit in the past year and did not use an e-cigarette in their recent quit attempt (mean [SD] age 41.6 [17.1] years; 445 [49.3%] women), and 1353 who quit in the past year and did not use nicotine replacement therapy in their recent quit attempt (mean [SD] age, 40.6 [16.6]; 631 [46.6%] women) in England completed the baseline Smoking Toolkit Study survey between January 2014 and September 2019. The subgroup of individuals (2014-2019) who had quit before 2011 included 14 241 respondents (mean [SD] age, 63.6 [14.6] years; 6619 [46.5%] women) (**Table 1**).

e-Cigarette Use Among Those Who Quit Smoking for More Than 1 Year

e-Cigarette use among those who quit more than 1 year ago increased from 3.30% (95% CI, 2.72%-3.96%) in 2014 to 10.36% (95% CI, 9.19%-11.62%) in 2019 among all socioeconomic groups. All

Table 1. Characteristics of Sample, Weighted Data

Variables	Participants, No. (%)			
	Quit >1 y (n = 19 297)[a]	Quit before 2011 (n = 14 241)[b]	Quit <1 y (n = 904)[c]	Quit <1 y (n = 1353)[d]
e-Cigarette use				
Yes	1361 (7.05)	155 (1.09)	67 (7.41)	NA
No	17 936 (92.95)	14 086 (98.91)	837 (92.59)	NA
NRT use				
Yes	590 (3.06)	317 (2.23)	NA	50 (3.69)
No	18 707 (96.94)	13 923 (97.77)	NA	1303 (96.31)
Sex				
Women	9024 (46.77)	6619 (46.48)	445 (49.26)	631 (46.59)
Age, y				
16-24	521 (2.70)	37 (0.26)	153 (16.87)	241 (17.84)
25-34	1814 (9.40)	596 (4.18)	241 (26.61)	340 (25.13)
35-44	2571 (14.26)	1707 (11.99)	193 (21.36)	300 (22.17)
45-54	3434 (17.80)	2463 (17.30)	143 (15.80)	228 (16.82)
55-64	3555 (18.42)	2885 (20.26)	92 (10.13)	139 (10.24)
≥65	7222 (37.42)	6552 (46.01)	83 (9.23)	106 (7.81)
SEP				
ABC1	11 408 (59.12)	8776 (61.63)	478 (52.89)	693 (51.22)
C2DE	7889 (40.88)	5464 (38.37)	426 (47.11)	660 (48.78)

Abbreviations: ABC1, higher and intermediate managerial, administrative and professional, supervisory occupations, and clerical and junior managerial occupations; C2DE, semiskilled and unskilled manual workers, state pensioners, casual and lowest-grade workers, and unemployed with state benefits only; NA, not applicable; NRT, nicotine replacement therapy; SEP, socioeconomic position.

Ns are weighted. ABC1 indicates a higher SEP; C2DE, a lower one.

[a] All participants who quit smoking for at least 1 year.

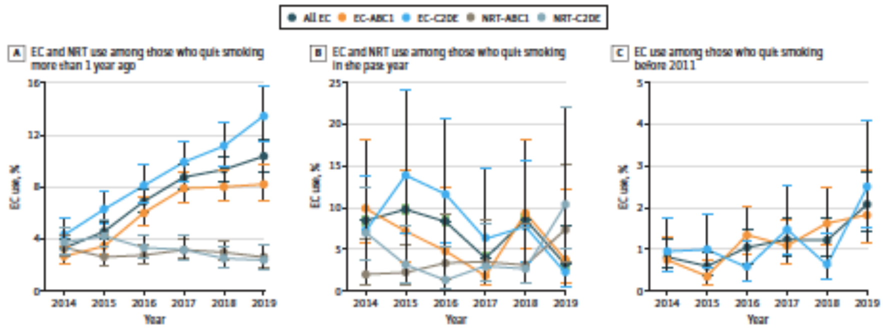
[b] Individuals who quit smoking before 2011.

[c] Individuals who quit smoking in the past year and did not use e-cigarettes in their most recent quit attempt.

[d] Individuals who quit smoking in the past year and did not use NRT in their most recent quit attempt.

respondents, regardless of socioeconomic position, were more likely to use e-cigarettes in each year from 2016 to 2019 compared with 2014 (eg, 2017: OR, 2.88; 95% CI, 2.06-4.09; $P < .001$; 2018: OR, 3.19; 95% CI, 2.29-4.54; $P < .001$; 2019: OR, 3.46; 95% CI, 2.45-4.97; $P < .001$) (**Figure**, A and **Table 2**). There were no significant interactions between socioeconomic position and time. Overall, respondents with lower socioeconomic position were more likely to use e-cigarettes compared with more affluent respondents (OR, 1.59; 95% CI, 1.05-2.40; $P = .03$). When stratified by year, this

Figure. Trends in e-Cigarette (EC) and Nicotine Replacement Therapy (NRT) Use Among Individuals Who Quit Smoking in England, 2014-2019



ABC1 indicates higher and intermediate managerial, administrative and professional, supervisory occupations, and clerical and junior managerial occupations; and C2DE, semiskilled and unskilled manual workers, state pensioners, casual and lowest-grade workers, and unemployed with state benefits only. Whiskers indicate 95% CIs.

Table 2. Associations Between e-Cigarette Use and Year of Survey and Socioeconomic Position[a]

Variable	Quit >1 y (n = 19 842)[b] OR (95% CI)	Quit >1 y P value	Quit <1 y (n = 870)[c] OR (95% CI)	Quit <1 y P value	Quit before 2011 (n = 15 063)[d] OR (95% CI)	Quit before 2011 P value
SEP						
ABC1	1 [Reference]		1 [Reference]		1 [Reference]	
C2DE	1.59 (1.05-2.40)	.03	0.54 (0.18-1.55)	.26	1.25 (0.47-3.21)	.62
Year						
2014	1 [Reference]		1 [Reference]		1 [Reference]	
2015	1.29 (0.88-1.90)	.20	0.54 (0.16-1.67)	.31	0.43 (0.13-1.22)	.13
2016	2.34 (1.66-3.37)	<.001	0.42 (0.09-1.52)	.21	1.93 (0.92-4.32)	.09
2017	2.88 (2.06-4.09)	<.001	0.18 (0.03-0.73)	.03	1.50 (0.68-3.47)	.32
2018	3.19 (2.29-4.54)	<.001	0.70 (0.22-2.10)	.54	2.79 (1.37-6.13)	.006
2019	3.46 (2.45-4.97)	<.001	0.31 (0.05-1.28)	.22	3.29 (1.56-7.40)	.005
Interaction terms						
2015 × C2DE	1.23 (0.73-2.10)	.44	4.63 (0.95-24.13)	.07	2.39 (0.56-10.9)	.25
2016 × C2DE	0.79 (0.48-1.31)	.36	4.53 (0.81-29.90)	.09	0.47 (0.12-1.72)	.26
2017 × C2DE	0.85 (0.52-1.37)	.50	7.21 (1.06-65.99)	.050	1.35 (0.41-4.57)	.63
2018 × C2DE	0.87 (0.54-1.40)	.57	1.39 (0.24-7.63)	.72	0.39 (0.11-1.37)	.15
2019 × C2DE	0.97 (0.59-1.60)	.67	1.70 (0.07-23.82)	.95	0.99 (0.30-3.31)	.98

Abbreviations: ABC1, higher and intermediate managerial, administrative and professional, supervisory occupations, and clerical and junior managerial occupations; C2DE, semiskilled and unskilled manual workers, state pensioners, casual and lowest-grade workers, and unemployed with state benefits only; LT, longterm; OR, odds ratio; PY, pastyear; SEP, socioeconomic position.

[a] Numbers are not weighted. All models are adjusted for age, sex, and region. Results for prevalence of e-cigarette use are presented as ORs (95% CI) against the indicated referent.

[b] All participants who quit smoking for at least 1 year.

[c] Individuals who quit smoking in the past year and did not use e-cigarettes in their most recent quit attempt.

[d] Individuals who quit smoking before 2011.

socioeconomic gradient in e-cigarette use remained, with the exception of 2016, when there was no clear evidence of an association with socioeconomic position (eg, 2017: OR, 1.33; 95% CI, 1.03-1.73; $P = .03$; 2018: OR, 1.35; 95% CI, 1.05-1.74; $P = .02$; 2019: OR, 1.59; 95% CI, 1.19-2.11; $P = .001$) (**Table 3**).

There was no clear trend in nicotine replacement therapy use across time or association between socioeconomic position and nicotine replacement therapy use, with the exception of 2015, in which individuals with lower socioeconomic position who had quit smoking for at least 1 year were more likely to use nicotine replacement therapy compared with those in the higher socioeconomic position group (OR, 1.66; 95% CI, 1.11-2.48; $P = .02$) (eTable 1 in the Supplement).

As a percentage of use in the general population, e-cigarette use increased from 10.53% (95% CI, 8.76%-12.60%) in 2014 to 30.48% (95% CI, 27.43%-33.72%) in 2019. This trend was also evident across socioeconomic position groups, increasing from 11.30% (95% CI, 8.73%-14.52%) to 31.88% (95% CI, 27.32%-36.81%) in the higher socioeconomic position group (higher and intermediate managerial, administrative and professional, supervisory, clerical, and junior managerial occupations) and 9.84% (95% CI, 7.59%-12.69%) to 29.36% (95% CI, 25.35%-33.71%) in the lower socioeconomic position group (semiskilled and unskilled manual workers, state pensioners, casual and lowest-grade workers, and unemployed with state benefits only) (eFigure 1 in the Supplement).

Recent Initiation of e-Cigarettes After Smoking Cessation in the Past Year

With the exception of 2017, in which e-cigarette use was less likely compared with 2014, there was no clear trend over time for e-cigarette use (Figure, B and Table 2) or nicotine replacement therapy use (eTable 1A in the Supplement) in this subgroup. With the exception of 2015, in which use was more likely among respondents with lower socioeconomic position, there were no apparent differences according to socioeconomic position in each year (OR, 3.46; 95% CI, 1.05-12.64; $P = .04$) (Table 3). There was little interaction between socioeconomic position and time. The exception was that use in the lower socioeconomic position group (semiskilled and unskilled manual workers, state pensioners,

Table 3. Associations Between e-Cigarette Use and Socioeconomic Position Stratified by Year

	2014		2015		2016		2017		2018		2019	
SEP	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Quit >1 y[a]												
No.	3170	NA	3462	NA	3533	NA	3617	NA	3532	NA	2528	NA
ABC1 (n = 12 008)	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA
C2DE (n = 7834)	1.64 (1.08-2.5)	.02	2.01 (1.43-2.82)	<.001	1.27 (0.95-1.7)	.10	1.33 (1.03-1.73)	.03	1.35 (1.05-1.74)	.02	1.59 (1.19-2.11)	.001
Quit <1 y[b]												
No.	194	NA	158	NA	129	NA	152	NA	152	NA	85	NA
ABC1 (n = 479)	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA
C2DE (n = 391)	0.61 (0.21-1.73)	.35	3.46 (1.05-12.64)	.04	2.24 (0.56-11.18)	.27	3.12 (0.61-23.06)	.20	0.80 (0.19-3.07)	.75	0.97 (0.04-11.07)	.63
Quit before 2011[c]												
No.	2683	NA	2805	NA	2703	NA	2649	NA	2501	NA	1722	NA
ABC1 (n = 9394)	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA
C2DE (n = 5669)	1.12 (0.42-2.87)	.81	3.22 (1.06-10.81)	.04	0.51 (0.18- 1.21)	.15	1.74 (0.81-3.74)	.15	0.45 (0.18-1.00)	.06	1.20 (0.56-2.47)	.52

Abbreviations: ABC1, higher and intermediate managerial, administrative and professional, supervisory occupations, and clerical and junior managerial occupations; C2DE, semiskilled and unskilled manual workers, state pensioners, casual and lowest-grade workers, and unemployed with state benefits only; NA, not applicable; OR, odds ratio; SEP, socioeconomic position.

Ns are not weighted. All models are adjusted for age, sex, and region. Results for prevalence of e-cigarette use are presented as ORs (95% CI) against the indicated referent. ABC1 indicates a higher SEP; C2DE, a lower one.

[a] All participants who quit smoking for at least 1 year.

[b] Individuals who quit smoking in the past year and did not use e-cigarettes in their most recent quit attempt.

[c] Individuals who quit smoking before 2011.

casual and lowest-grade workers, and unemployed with state benefits only) depended on year, with higher comparative prevalence in 2017 compared with 2014 (OR, 7.21; 95% CI, 1.06-66.0; $P = .050$).

Overall, e-cigarette use as a percentage of use in the general population decreased from 1.72% (95% CI, 1.07%-2.74%) in 2014 to 0.37% (95% CI, 0.12%-1.07%) in 2019 (eFigure 2 in the Supplement). In the higher socioeconomic position group, use decreased from 2.17% (95% CI, 1.19%-3.95%) in 2014 to 0.54% (95% CI, 0.15%-1.96%) in 2019. In the lower socioeconomic position group, use decreased from 1.5% (95% CI, 0.77%-2.96%) in 2014 to 0.22% (95% CI, 0.04%-1.24%) in 2019.

Late Initiation of e-Cigarettes Among Individuals Who Quit Smoking Before 2011

A trend in e-cigarette use across time was evident, whereby all respondents, regardless of socioeconomic position, were more likely to use e-cigarettes in 2018 (OR, 2.79; 95% CI, 1.37-6.13; $P = .006$) and 2019 (OR, 3.29; 95% CI, 1.56-7.40; $P = .005$) compared with 2014 (Figure, C and Table 2). There were no interactions between socioeconomic position and time. With the exception of 2015, in which use was more likely among respondents with lower socioeconomic position (OR, 3.22; 95% CI, 1.06-10.81; $P = .04$) , there were no apparent differences according to socioeconomic position in each year (Table 3).

Overall e-cigarette use among those who quit smoking before 2011 as a percentage of use in the general population was estimated to have increased from 2.23% (95% CI, 1.47%-3.35%) in 2014 to 4.02% (95% CI, 2.88%-5.60%) in 2019 (eFigure 3 in the Supplement). In the higher socioeconomic position group, use increased from 2.82% (95% CI, 1.66%-4.77%) in 2014 to 4.90% (95% CI, 3.12%-7.62%) in 2019. In the lower socioeconomic position group, use increased from 1.70% (95% CI, 0.90%-3.21%) in 2014 to 3.31% (95% CI, 2.02%-5.39%) in 2019.

Sensitivity Analyses

In a sensitivity analysis, we used housing tenure as an alternative measure of socioeconomic position. This yielded a pattern of results similar to that of the main analysis (eTables 2 and eTable 3 in the Supplement).

Discussion

From 2014 to 2019 in England, e-cigarette use increased among individuals who had quit smoking for more than 1 year and was highest among respondents with lower socioeconomic position. Among those who quit smoking in the past year and did not use an e-cigarette during their most recent quit attempt, there were no clear trends over time or socioeconomic differences in e-cigarette use. Use among those who quit smoking before 2011 was greater in 2018 and 2019 compared with 2014, but there was no clear evidence of a difference according to socioeconomic position throughout the period.

The findings on e-cigarette use among those who quit smoking for more than 1 year reveal a continuation of the trends observed in previous Smoking Toolkit Study data from England,[12] with overall increased use over time and greater use among respondents with lower socioeconomic position compared with those with higher socioeconomic position. This is concordant with recently published data from the UK Household Longitudinal Study, in which socioeconomic disadvantage was associated with e-cigarette use among adults who formerly smoked.[14] However, this recent study included respondents who self-reported as currently, formerly, or never smoked and could not explore e-cigarette use in specific subcategories of these groups, as we have attempted to do in this study.

Findings from the US population, in which e-cigarettes are similarly popular, appear to show a divergent trend, whereby e-cigarette use is more likely among individuals with socioeconomic advantage who used to smoke.[11,12] This heterogeneity in e-cigarette use by socioeconomic position between different countries was highlighted by a 2019 systematic review in which analysis of studies from 11 countries found mixed patterns of e-cigarette current use by socioeconomic position.[23] Such differences may be a reflection of different health policy and advocacy environments toward e-cigarettes in England compared with other countries in which the devices have become popular. However, these comparisons are made with caution; more granular data on e-cigarette use by smoking status are required from other contexts before direct comparisons with the UK can be made.

In this study, individuals who had quit smoking for more than 1 year were also found to make up an increasing percentage of e-cigarette users in the general population. These results likely reflect the continued use of e-cigarettes after smoking cessation. Comparing the trends in use by socioeconomic position highlights that although there have been consistent increases among those who quit smoking for more than 1 year with lower socioeconomic position, this is not apparent among respondents with higher socioeconomic position, whose use appears to have stabilized. Such socioeconomic patterning in e-cigarette use is important, considering that studies have shown that those who formerly smoked and now vape reported greater confidence in not smoking compared with those who do not vape.[16,24] This is contextualized by the absence of a trend in the use of nicotine replacement therapy, another widely available nicotine product, across the period. However, a 2019 randomized clinical trial that showed e-cigarettes to be almost twice as effective for smoking cessation at 1 year compared with nicotine replacement therapy[3] has indicated that, in the context of the trial, the devices may not confer extra protection against relapse. The trial found that time to relapse and relapse rates among participants with sustained abstinence at 4 weeks were similar between the 2 trial groups despite large differences in ongoing use (80% of individuals in the e-cigarette arm were using their allocated product at 52 weeks compared with 9% in the nicotine replacement therapy arm). Nicotine replacement therapy is likely more widely used as a medium-term quitting aid, unlike e-cigarettes, which appear more popular for longer-duration use. Therefore, compared with nicotine replacement therapy, the added value of e-cigarettes may not be because of greater protection against relapse, but rather because of greater efficacy for smoking cessation.[25]

The current absence of evidence on relapse protection along with increasing levels of prolonged use among individuals with lower socioeconomic position who formerly smoked make this area an urgent research priority. If e-cigarettes do not confer the public health benefit of protection against relapse to smoking, then equity-negative outcomes of long-term usage are more likely because although safer than smoking, use of the devices is not without risk.

The use of e-cigarettes among individuals who quit smoking in the past year and did not use an e-cigarette in their most recent quit attempt did not appear to change over time or differ by socioeconomic position. Therefore, any potentially positive or negative outcomes from the use of e-cigarettes at the population level will likely affect people equally across the socioeconomic spectrum, making it unlikely that use in this specific subgroup will have a substantial effect on smoking-related health inequalities.

The use of e-cigarettes among individuals who quit smoking before 2011 increased over time overall and was significantly higher toward the end of the period compared with 2014. This subgroup also made up an increasing percentage of e-cigarette users in the general population. Although the change appears modest, it suggests that in addition to continued e-cigarette use as a quitting aid, increases in their use may in part be due to late initiation among individuals who have already quit smoking. Those who quit smoking before 2011 represent those who quit smoking before e-cigarettes arrived on the UK market. This older (mean age, 63.6 years) subgroup may have taken up e-cigarettes to prevent relapse to tobacco smoking or because of the attractive nicotine delivery properties and decreased harm profile of the devices. Some researchers may view the latter as relapse to nicotine dependence. Given that these individuals had maintained abstinence from smoking without any assistance from e-cigarettes, it is plausible that they would have been able to remain abstinent in their absence. Our findings suggest that the initiation of e-cigarettes in this group is unlikely to affect health inequalities, but further research is needed to understand the reasons behind the observed increase in use overall. Recent prospective research in the US has suggested that use of e-cigarettes in this subgroup may increase the likelihood of a return to tobacco smoking.[26]

If the devices were increasing the likelihood of a return to smoking in England, then we would expect the prevalence of e-cigarette use among this group to stabilize or decline as many of them return to smoking. This is unlikely according to evidence from this study. Furthermore, we would also expect to observe a decrease in the rate of reduction of smoking after the advent of e-cigarettes. This does not appear to be the case, with consistent reductions in smoking year after year.[2] Respondents in the sample of individuals who quit smoking some time ago in the aforementioned US study who reported relapsing to combustible tobacco smoking in the past 30 days were more likely to be younger (18-34 vs ≥35 years). This may represent a phenomenon unique to the US context, in which, although strongly associated with lifetime tobacco use and perhaps a reflection of common liability to addiction, youth e-cigarette use has sharply increased in recent years.[27-29] This is in contrast to the United Kingdom, in which weekly e-cigarette use among former smoking youths (11-18 years) is estimated to be 3.3%[30] and almost negligible among those who never smoked.

Strengths and Limitations

Strengths of this study include its large representative sample of the population in England, allowing a detailed and generalizable interrogation of e-cigarette use over time in specific subgroups of individuals who formerly smoked. Furthermore, the use of a different measure of socioeconomic position in a sensitivity analysis provided results convergent with those of the main analysis. However, the results are limited by the use of self-reported cross-sectional survey data, in which smoking status was not biochemically verified. It is also challenging to measure e-cigarette consumption levels accurately without a validated quantifiable measure.

Conclusions

This study found that from 2014 to 2019 in England, e-cigarette use increased among all individuals who had quit smoking for more than 1 year and was most likely among respondents with lower socioeconomic position. Use among those who quit in the past year and did not use an e-cigarette in their most recent quit attempt was similar over time and by socioeconomic position. Among individuals who quit smoking before 2011, e-cigarette use has increased since 2014, but there were no differences according to socioeconomic position. Therefore, this socioeconomically patterned use of e-cigarettes is unlikely because of recent or late initiation of e-cigarettes after quitting and probably reflects continued use of e-cigarettes as a long-term cessation aid in individuals of lower socioeconomic position.

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REFERENCES

1. Hiscock R, Bauld L, Amos A, Fidler JA, Munafò M. Socioeconomic status and smoking: a review. *Ann N Y Acad Sci.* 2012;1248(1):107-123. doi:10.1111/j.1749-6632.2011.06202.x

2. Brown J, West R. Latest trends on smoking in England from the Smoking Toolkit Study. Updated January 10, 2020. Accessed January 17, 2019. www.smokinginengland.info/latest-statistics

3. Hajek P, Phillips-Waller A, Przulj D, et al. A randomized trial of e-cigarettes versus nicotine-replacement therapy. *N Engl J Med.* 2019;380(7):629-637. doi:10.1056/NEJMoa1808779

4. Beard E, West R, Michie S, Brown J. Association between electronic cigarette use and changes in quit attempts, success of quit attempts, use of smoking cessation pharmacotherapy, and use of stop smoking services in England: time series analysis of population trends. *BMJ.* 2016;354:i4645. doi:10.1136/bmj.i4645

5. Shahab L, Goniewicz ML, Blount BC, et al. Nicotine, carcinogen, and toxin exposure in long-term e-cigarette and nicotine replacement therapy users: a cross-sectional study. *Ann Intern Med.* 2017;166(6):390-400. doi:10.7326/M16-1107

6. Stephens WE. Comparing the cancer potencies of emissions from vapourised nicotine products including e-cigarettes with those of tobacco smoke. *Tob Control.* 2017;27(1):10-17. doi:10.1136/tobaccocontrol-2017-053808

7. National Academies. Stratton K, Kwan LY, Eaton DL, eds. *Public Health Consequences of e-Cigarettes.* National Academies Press; 2018.

8. Mcneill A, Brose LS, Calder R, Bauld L, Robson D. Evidence review of e-cigarettes and heated tobacco products 2018: a report commissioned by Public Health England. Updated March 2, 2018. Accessed March 30, 2020. https://www.gov.uk/government/publications/e-cigarettes-and-heated-tobacco-products-evidence-review/evidence-review-of-e-cigarettes-and-heated-tobacco-products-2018-executive-summary

9. Niblett P. Statistics on smoking: England, 2019. Accessed March 30, 2020. https://digital.nhs.uk/data-and-information/publications/statistical/statistics-on-smoking/statistics-on-smoking-england-2019

10. Action on Smoking and Health. Fact sheets. Accessed February 24, 2020. https://ash.org.uk/fact-sheets/

11. Friedman AS, Horn SJL. Socioeconomic disparities in electronic cigarette use and transitions from smoking. *Nicotine Tob Res.* 2019;21(10):1363-1370. doi:10.1093/ntr/nty120

12. Harlow AF, Stokes A, Brooks DR. Socioeconomic and racial/ethnic differences in e-cigarette uptake among cigarette smokers: longitudinal analysis of the Population Assessment of Tobacco and Health (PATH) Study. *Nicotine Tob Res.* 2019;21(10):1385-1393. doi:10.1093/ntr/nty141

13. Kock L, Shahab L, West R, Brown J. E-cigarette use in England 2014-17 as a function of socio-economic profile. *Addiction.* 2018;114(2):294-303. doi:10.1111/add.14446

14. Green MJ, Gray L, Sweeting H, Benzeval M. Socioeconomic patterning of vaping by smoking status among UK adults and youth. *BMC Public Health.* 2020;20(1):183. doi:10.1186/s12889-020-8270-3

15. Siahpush M, McNeill A, Borland R, Fong GT. Socioeconomic variations in nicotine dependence, self-efficacy, and intention to quit across four countries: findings from the International Tobacco Control (ITC) Four Country Survey. *Tob Control.* 2006;15(suppl 3):iii71-iii75. doi:10.1136/tc.2004.008763

16. Notley C, Ward E, Dawkins L, Holland R. The unique contribution of e-cigarettes for tobacco harm reduction in supporting smoking relapse prevention. *Harm Reduct J*. 2018;15(1):31. doi:10.1186/s12954-018-0237-7

17. Thirlway F. How will e-cigarettes affect health inequalities? applying Bourdieu to smoking and cessation. *Int J Drug Policy*. 2018;54:99-104. doi:10.1016/j.drugpo.2018.01.009

18. Fidler JA, Shahab L, West O, et al. The Smoking Toolkit Study: a national study of smoking and smoking cessation in England. *BMC Public Health*. 2011;11:479. doi:10.1186/1471-2458-11-479

19. Knottnerus A, Tugwell P. STROBE: a checklist to Strengthen the Reporting of Observational Studies in Epidemiology. *J Clin Epidemiol*. 2008;61(4):323. doi:10.1016/j.jclinepi.2007.11.006

20. National Readership Survey. Social grade. Accessed November 24, 2017. http://www.nrs.co.uk/nrs-print/lifestyle-and-classification-data/social-grade/

21. Jackson SE, Smith C, Cheeseman H, West R, Brown J. Finding smoking hot-spots: a cross-sectional survey of smoking patterns by housing tenure in England. *Addiction*. 2019;114(5):889-895. doi:10.1111/add.14544

22. Department for Communities and Local Government. English Housing Survey: guidance and methodology. Accessed December 6, 2017. https://www.gov.uk/guidance/english-housing-survey-guidance-and-methodology#about-the-english-housing-survey

23. Lucherini M, Hill S, Smith K. Potential for non-combustible nicotine products to reduce socioeconomic inequalities in smoking: a systematic review and synthesis of best available evidence. *BMC Public Health*. 2019;19(1):1469. doi:10.1186/s12889-019-7836-4

24. McNeill A, Driezen P, Hitchman SC, Cummings KM, Fong GT, Borland R. Indicators of cigarette smoking dependence and relapse in former smokers who vape compared with those who do not: findings from the 2016 International Tobacco Control Four Country Smoking and Vaping Survey. *Addiction*. 2019;114(S1)(suppl 1):49-60. doi:10.1111/add.14722

25. Stapleton J. Perverse conclusion from results. Published January 18, 2012. Accessed December 17, 2019. https://tobaccocontrol.bmj.com/content/perverse-conclusion-results

26. McMillen R, Klein JD, Wilson K, Winickoff JP, Tanski S. E-cigarette use and future cigarette initiation among never smokers and relapse among former smokers in the PATH study. *Public Health Rep*. 2019;134(5):528-536. doi:10.1177/0033354919864369

27. Vanyukov MM, Tarter RE, Kirillova GP, et al. Common liability to addiction and "gateway hypothesis": theoretical, empirical and evolutionary perspective. *Drug Alcohol Depend*. 2012;123(suppl 1):S3-S17. doi:10.1016/j.drugalcdep.2011.12.018

28. Berry KM, Fetterman JL, Benjamin EJ, et al. Association of electronic cigarette use with subsequent initiation of tobacco cigarettes in US youths. *JAMA Netw Open*. 2019;2(2):e187794. doi:10.1001/jamanetworkopen.2018.7794

29. Jarvis M, West R, Brown J. Epidemic of youth nicotine addiction? what does the National Youth Tobacco Survey reveal about high school e-cigarette use in the USA? Published October 7, 2019. Accessed March 30, 2020. https://www.qeios.com/read/article/391

30. Action on Smoking and Health. Use of e-cigarettes among young people in Great Britain. Published June 18, 2019. Accessed November 27, 2019. https://ash.org.uk/wp-content/uploads/2019/06/ASH-Factsheet-Youth-E-cigarette-Use-2019.pdf

SUPPLEMENT.

eTable 1. Associations Between Nicotine Replacement Therapy, Year, and Socioeconomic Position
eTable 2. Associations Between e-Cigarette Use and Year of Survey and SEP (Housing Tenure) in England, 2014 to 2019
eTable 3. Associations Between e-Cigarette Use and SEP (Housing Tenure) Stratified by Year in England, 2014-2019
eFigure 1. EC and NRT Use Among Those Who Quit Smoking for More Than 1 Year as a Percentage of Respective Use in the General Population
eFigure 2. EC Use Among Those Who Quit Smoking in the Past Year and Did not Use ECs in Quit Attempt as a Percentage of Respective Use in the General Population
eFigure 3. Current e-Cigarette Use Among Those Who Quit Smoking Before 2011 as a Percentage of Use in the General Population

Appendix 4 – Chapter 2 (Study 1) supplementary material

GRADE ratings and their interpretation

Symbol	Certainty*	Interpretation
⊕⊕⊕⊕	**High**	We are very confident that the true effect lies close to that of the estimate of the effect.
⊕⊕⊕⊖	**Moderate**	We are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
⊕⊕⊖⊖	**Low**	Our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
⊕⊖⊖⊖	**Very low**	We have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

The GRADE system rates the quality/certainty of evidence for each outcome from a rating of high to very low after considering and making a judgement based 8 assessment criteria (Risk of Bias, Inconsistency, Indirectness, Imprecision, and Publication Bias). Table taken from the GRADE Handbook, available at http://gdt.guidelinedevelopment.org/app/handbook/handbook.html#h.9rdbelsnu4iy

Risk of bias summary

Five studies were judged to be at high risk of bias due to potential deviations from the intended interventions in the trial. Examples of this include poor participation in or adherence to intervention components (such as behavioural support sessions or use of digital intervention, and use of pharmacotherapy).

Studies that reported biochemically validated abstinence were judged to be at low risk of bias for measurement of the outcome. Seven studies where abstinence was self-reported and not validated biochemically were judged to be at high risk of bias.

The risk of bias from missing outcome data was judged to be low if loss to follow-up was low and similar across arms in the trial. Five studies were judged to be at high risk of bias due to high drop out and/or unequal follow-up between different trial arms.

Most studies were judged to be at low risk of bias in selective reporting of results due to adherence to trial protocols and pre-specified sample power calculations.
Overall, six of the 42 included studies were classified as being at low risk of bias on all domains considered in the assessment.

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Most studies were judged to be at low risk of bias in selective reporting of results due to adherence to trial protocols and pre-specified sample power calculations.

Overall, six of the 42 included studies (15%) were classified as being at low risk of bias on all domains considered in the assessment.

Formulas for calculation of pooled effect estimates in random effects meta-analysis

The weight (W_i) of each study in the meta-analysis is given by

$$W_i = 1 / V_i + T^2$$

where V_i is the within-study variance for each study (i) and T^2 it's between-studies variance, tau-squared).

The weighted effect size X^w is calculated as the sum of the products (effect size X multiplied by weight) divided by the sum of the weights

$$X^w = \frac{\Sigma W_i X}{\Sigma W_I}$$

The variance v of the pooled effect is given by

$$v = \frac{1}{\Sigma w_i}$$

and the standard error is computed as the square root of the variance. The 95% confidence intervals for the pooled estimate is then computed as

$$X^w \pm 1.96 \times SE(X^w)$$

Sub-group analysis: comparing non-SEP-tailored interventions in low and high SEP participants

To test whether the estimates in each sub-group are different from each other, we fit two separate random-effects models within each subset (low SEP and high SEP) defined by

the SEP variable. The SEP variable indicated whether the sample for analysis was ‘low’ or ‘high’ SEP.
We then combined the estimates and standard errors from each model into a data frame. A variable was added to distinguish the two models and for reasons explained below, we added the estimated amounts of heterogeneity within each subset to the data frame.
To compare the two estimates (average log risk-ratios), they were fed back into a meta-analysis model using the model variable to distinguish the two estimates as a moderator (highSEP vs lowSEP). A fixed effect model was used because the residual heterogeneity within each respective subset had already been accounted for by fitting the random-effects models outlined above. The model output is provided below with results in table s3:
Fixed-effects with moderators model

Test for Residual Heterogeneity: QE(df = 0) = 0.000, p-val = 1.000

Test of Moderators (coefficient 2): QM(df = 1) = 0.000, p-val = 0.904

Egger’s regression test

<u>Non-SEP-tailored interventions (low-SEP participants)</u>

Regression Test for Funnel Plot Asymmetry

Model: mixed-effects meta-regression model

Predictor: standard error

Test for funnel plot asymmetry: z = 1.6264, p = 0.1039

<u>Non-SEP-tailored interventions (high-SEP participants)</u>

Regression Test for Funnel Plot Asymmetry

Model: mixed-effects meta-regression model

Predictor: standard error

Test for funnel plot asymmetry: z = 2.3376, p = 0.0194

However, given the high levels of heterogeneity and relatively small number of studies included in the test for asymmetry, the analysis may not be sufficiently powered to distinguish between real asymmetry and chance.

Data extraction reliability

HTB extracted 10% of all study data using the same data extraction form as the primary reviewer (LK). The level of agreement below is calculated based on comparing the data points extracted by LK and HTB for each domain. Any differences between extracted data were discussed and resolved.

Smoking cessation outcome data (used in intention to treat analysis)

Disagree	1
Agree	51

Total	52
% Agreement	98.1

Trial description data

Disagree	0
Agree	32
Total	32
% Agreement	100

Patient demographics

Disagree	0
Agree	45
Total	45
% Agreement	100

TIDieR

Disagree	4
Agree	230
Total	234
% Agreement	98.3

Pharmacotherapy data

Disagree	0
Agree	24
Total	24
% Agreement	100

Appendix 5 – Chapter 3 (study 2) sensitivity analyses

Daily e-cigarette use

Table A5.1: Prevalence of daily e-cigarette use in England among all adults 2014-2017 stratified by social grade

	Overall (N=81033)	2014 (N=20189)	2015 (N=20031)	2016 (N=20430)	2017 (N=20383)
Social Grade					
AB (N=18960) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=25564)	**1·31 (1·01-1·72)**	**1·33 (1·03-1·74)**	**1·39 (1·08-1·80)**	**1·26 (1·02-1·58)**	**1·47 (1·17-1·84)**
C2 (N=16186)	**1·73*** (1·33-2·28)**	**1·77*** (1·35-2·33)**	**1·77*** (1·36-2·31)**	**1·71*** (1·36-2·15)**	**1·73 (1·35-2·21)**
D (N=11957)	**1·44 (1·07-1·95)**	**1·49 (1·10-2·01)**	**2·21*** (1·69-2·90)**	**1·75*** (1·36-2·24)**	**1·69 (1·28-2·22)**
E (N=8366)	**1·92*** (1·40-2·62)**	**1·99*** (1·45-2·74)**	**2·05*** (1·53-2·75)**	1·34 (0·99-1·80)	**2·89 (2·20-3·79)**

Ns are not weighted. Results for prevlance of e-cigarette use are presented as ORs (95% CI) against the indicated referent. <0·05 p values are indicated in bold. *p<0·01, **p<0·001, ***p<0.0001. Daily e-cigarette use includes respondents who report daily e-cigarette use.

Table A5.2: Prevalence daily of e-cigarette use in England among past-year smokers 2014-2017 stratified by social grade

	Overall (N=16090)	2014 (N=4250)	2015 (N=4198)	2016 (N=3965)	2017 (N=3677)
Social Grade					
AB (N=2033) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=4432)	0·84 (0·62-1·16)	0·85 (0·62-1·17)	0·85 (0·63-1·17)	0·77 (0·57-1·03)	0·94 (0·68-1·31)
C2 (N=3710)	0·79 (0·57-1·08)	0·78 (0·57-1·08)	0·73 (0·53-1·01)	0·95 (0·51-1·27)	0·91 (0·65-1·29)
D (N=3143)	**0·57* (0·40-0·81)**	**0·57* (0·40-0·81)**	0·90 (0·66-1·24)	**0·70 (0·51-0·97)**	0·78 (0·54-1·13)
E (N=2772)	**0·60* (0·42-0·86)**	**0·61 (0·43-0·87)**	**0·58* (0·41-0·82)**	**0·48*** (0·33-0·68)**	1·09 (0·77-1·58)

Ns are not weighted. Results for prevlance of e-cigarette use are presented as ORs (95% CI) against the indicated referent. <0·05 p values are indicated in bold. *p<0·01, **p<0·001, ***p<0.0001. Daily e-cigarette use includes respondents who report daily e-cigarette use.

Table A5.3: Prevalence of e-cigarette use in England among quit attempters 2014-2017 stratified by social grade

	Overall (N=4827)	2014 (N=1412)	2015 (N=1226)	2016 (N=1070)	2017 (N=1119)
Social Grade					
AB (N=703) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=1402)	0·86 (0·54-1·39)	0·90 (0·56-1·46)	1·07 (0·66-1·75)	**0·63** **(0·41-0·99)**	0·92 (0·57-1·52)
C2 (N=1101)	1·04 (0·65-1·68)	1·04 (0·65-1·70)	1·06 (0·64-1·78)	1·23 (0·80-1·90)	1·22 (0·74-2·04)
D (N=846)	0·69 (0·40-1·17)	0·72 (0·42-1·23)	1·35 (0·81-2·26)	0·69 (0·41-1·15)	1·29 (0·76-2·23)
E (N=775)	0·79 (0·47-1·35)	0·85 (0·50-1·46)	0·62 (0·35-1·10)	**0·46*** **(0·25-0·81)**	0·92 (0·52-1·61)

Ns are not weighted. Results for prevlance of e-cigarette use are presented as ORs (95% CI) against the indicated referent. <0·05 p values are indicated in bold. *p<0·01, **p<0·001, ***p<0.0001. Daily e-cigarette use includes respondents who report daily e-cigarette use.

Table A5.4: Prevalence of e-cigarette use in England among long-term ex-smokers 2014-2017 stratified by social grade

	Overall (N=13773)	2014 (N=3169)	2015 (N=3462)	2016 (N=3530)	2017 (N=3612)
Social Grade					
AB (N=3949) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=4300)	1·22 (0·60-2·58)	1·22 (0·60-2·60)	1·84 (0·99-3·62)	1·36 (0·91-2·07)	1·40 (0·95-2·06)
C2 (N=2882)	**2·09** **(1·05-4·40)**	**2·15** **(1·07-4·54)**	**3·30**** **(1·77-6·48)**	1·18 (0·73-1·89)	**1·54** **(1·01-2·34)**
D (N=1541)	**2·38** **(1·09-5·28)**	**2·44** **(1·11-5·45)**	**3·37*** **(1·64-7·06)**	**2·25*** **(1·38-3·65)**	1·36 (0.80-2·24)
E (N=1101)	1·16 (0·32-3·40)	1·15 (0·31-3·40)	**3·08*** **(1·41-6·72)**	0·57 (0·21-1·28)	**2·17*** **(1·25-3·67)**

Ns are not weighted. Results for prevlance of e-cigarette use are presented as ORs (95% CI) against the indicated referent. <0·05 p values are indicated in bold. *p<0·01, **p<0·001, ***p<0.0001. Daily e-cigarette use includes respondents who report daily e-cigarette use.

Weekly e-cigarette use

Table A5.5: Prevalence of e-cigarette use in England among all adults 2014-2017 stratified by social grade

	Overall (N=81033)	2014 (N=20189)	2015 (N=20031)	2016 (N=20430)	2017 (N=20383)
Social Grade					
AB (N=18960) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=25564)	**1·89 (1·16-3·21)**	**1·95 (1·19-3·31)**	1·56 (0·99-2·49)	**2·02* (1·24-3·42)**	1·09 (0·70-1·72)
C2 (N=16186)	**1·78 (1·05-3·11)**	**1·83 (1·08-3·21)**	**1·71 (1·06-2·81)**	**2·05* (1·20-3·59)**	**1·62 (1·02-2·59)**
D (N=11957)	1·65 (0·92-2·98)	1·69 (0·94-3·08)	**2·18* (1·35-3·59)**	**2·25* (1·26-4·08)**	1·25 (0·72-2·14)
E (N=8366)	**3·22*** (1·86-5·72)**	**3·26*** (1·88-5·83)**	**1·87 (1·09-3·22)**	**3·79*** (2·16-6·77)**	1·12 (0·56-2·10)

Ns are not weighted. Results for prevlance of e-cigarette use are presented as ORs (95% CI) against the indicated referent. <0·05 p values are indicated in bold. *p<0·01, **p<0·001, ***p<0.0001. Weekly e-cigarette use includes respondents who report at least weekly e-cigarette use.

Table A5.6: Prevalence of e-cigarette use in England among all past year smokers 2014-2017 stratified by social grade

	Overall (N=16090)	2014 (N=4250)	2015 (N=4198)	2016 (N=3965)	2017 (N=3677)
Social Grade					
AB (N=2033) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=4432)	1·19 (0·71-2·07)	1·24 (0·74-2·17)	0·99 (0·61-1·66)	**1·84 (1·03-3·48)**	0·64 (0·40-1·05)
C2 (N=3710)	0·83 (0·48-1·49)	0·86 (0·49-1·53)	0·79 (0·47-1·36)	1·34 (0·71-2·61)	0·75 (0·45-1·25)
D (N=3143)	0·70 (0·39-1·30)	0·74 (0·40-1·37)	0·88 (0·52-1·51)	1·23 (0·63-2·49)	**0·48 (0·26-0·86)**
E (N=2772)	1·06 (0·60-1·92)	1·07 (0·61-1·96)	0·64 (0·36-1·14)	1·72 (0·91-3·39)	**0·32* (0·15-0·63)**

Ns are not weighted. Results for prevlance of e-cigarette use are presented as ORs (95% CI) against the indicated referent. <0·05 p values are indicated in bold. *p<0·01, **p<0·001, ***p<0.0001. Weekly e-cigarette use includes respondents who report at least weekly e-cigarette use.

Table A5.7: Prevalence of e-cigarette use in England among quit attempterss 2014-2017 stratified by social grade

	Overall (N=4827)	2014 (N=1412)	2015 (N=1226)	2016 (N=1070)	2017 (N=1119)
Social Grade					
AB (N=703) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=1402)	1·16 (0·47-3·48)	1·07 (0·43-3·06)	1·30 (0·58-3·22)	1·40 (0·45-5·21)	0·74 (0·33-1·71)
C2 (N=1101)	0·80 (0·29-2·38)	0·75 (0·27-2·27)	1·04 (0·42-2·71)	1·68 (0·55-6·23)	0·82 (0·35-1·94)
D (N=846)	1·30 (0·50-3·78)	1·23 (0·46-3·63)	1·37 (0·57-3·53)	2·50 (0·80-9·45)	0·52 (0·17-1·44)
E (N=775)	1·11 (0·40-3·34)	1·00 (0·36-3·05)	1·10 (0·43-2·91)	3·37 (1·11-12·53)	0·44 (0·13-1·26)

Ns are not weighted. Results for prevlance of e-cigarette use are presented as ORs (95% CI) against the indicated referent. <0·05 p values are indicated in bold. *p<0·01, **p<0·001, ***p<0.0001. Weekly e-cigarette use includes respondents who report at least weekly e-cigarette use.

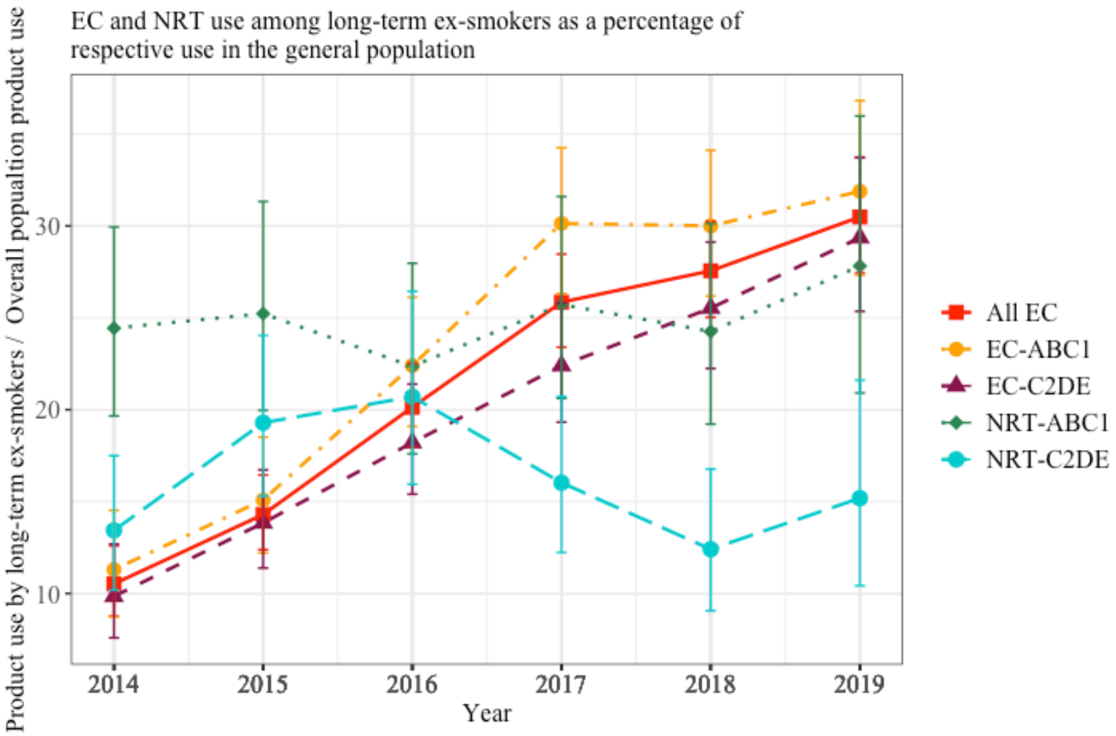
Table A5.8: Prevalence of e-cigarette use in England among long-term ex-smokers 2014-2017 stratified by social grade

	Overall (N=13773)	2014 (N=3169)	2015 (N=3462)	2016 (N=3530)	2017 (N=3612)
Social Grade					
AB (N=3949) ref	1·00 -	1·00 -	1·00 -	1·00 -	1·00 -
C1 (N=4300)	1·84 (0·23-37·37)	1·72 (0·21-35·56)	1·76 (0·48-8·31)	0·25 (0·01-2·01)	1·82 (0·47-8·72)
C2 (N=2882)	1·02 (0·04-26·03)	1·05 (0·04-27·21)	2·06 (0·49-10·31)	0·31 (0·01-2·72)	2·09 (0·04-10·86)
D (N=1541)	1·98 (0·08-50·67)	2·08 (0·08-55·20)	**4·77** (1·13-23·89)	0·68 (0·03-5·72)	1·89 (0·24-11·87)
E (N=1101)	3·38 (0·13-86·94)	2·82 (0·10-78·06)	4·17 (N/A)	2·28 (0·11-19·89)	1·60 (0·08-13·35)

Ns are not weighted. Results for prevlance of e-cigarette use are presented as ORs (95% CI) against the indicated referent. <0·05 p values are indicated in bold. *p<0·01, **p<0·001, ***p<0.0001. Weekly e-cigarette use includes respondents who report at least weekly e-cigarette use

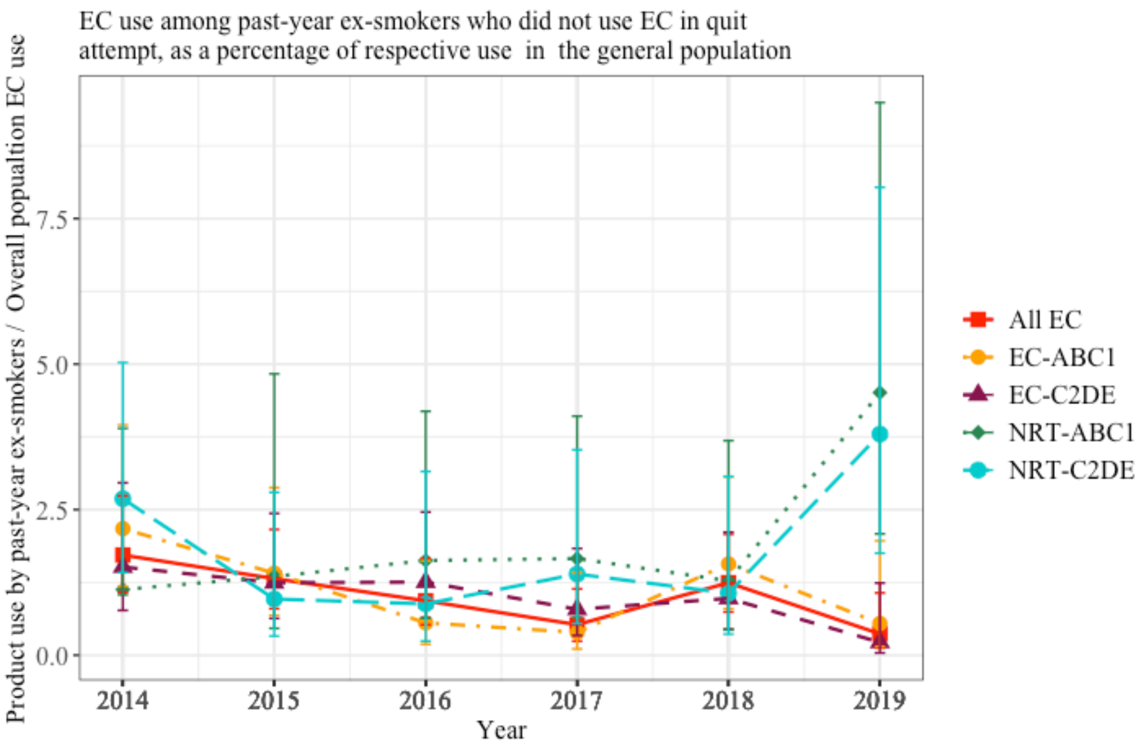
Appendix 6 – Chapter 4 (Study 3) sensitivity analyses

Figure A6.1



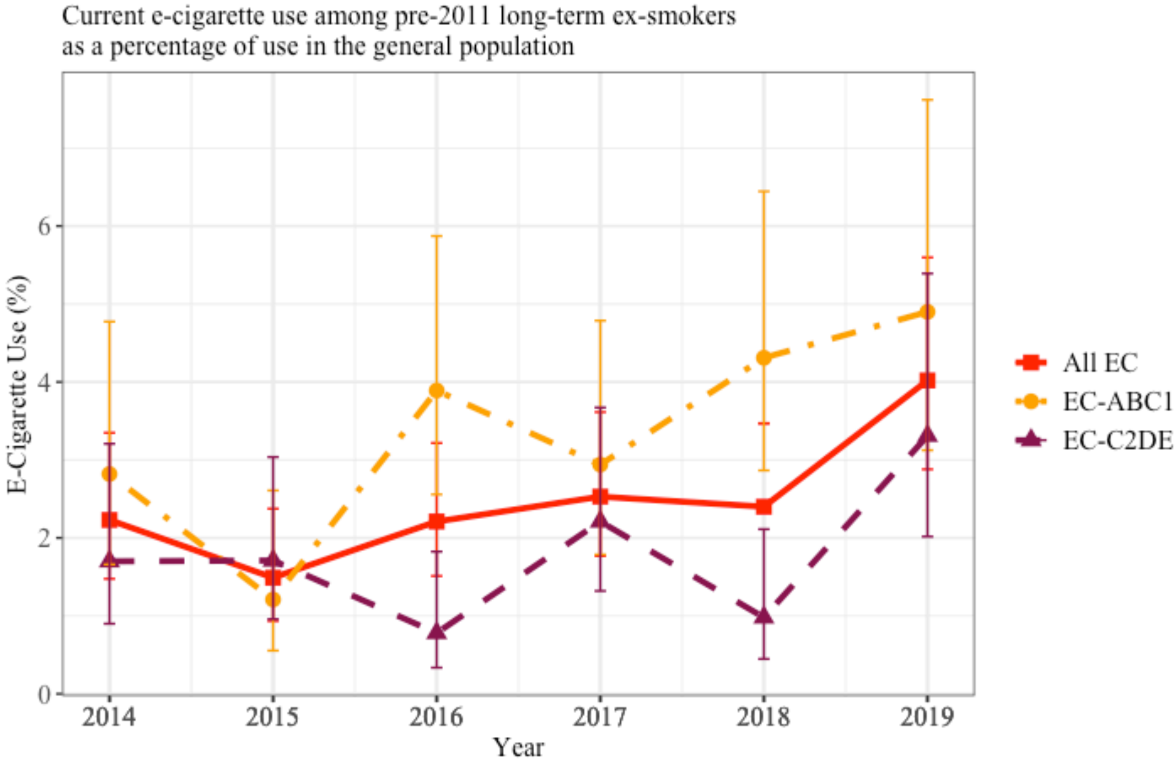
Ns are weighted

Figure A6.2



Ns are weighted

Figure A6.3



Ns are weighted

Table A6.1: Associations between e-cigarette use and year of survey and SEP (housing tenure) among i) long-term ex-smokers, ii) past-year ex-smokers and iii) pre-2011 long-term ex-smokers in England (2014-2019).

	Long term ex-smokers[a]	***P***	**PY ex-smokers[b]**	***P***	**Pre-2011 LT ex-smokers[c]**	***P***
	(N=19842)		(N=870)		(N=15063)	
SEP						
Other	1 [reference]		1 [reference]		1 [reference]	
Social housing	2.25 (1.39-3.55)	<.001	1.89 (0.55- 5.79)	.28	1.21 (0.28 - 3.73)	.77
Year						
2014 ref	1 [reference]	.01	1 [reference]		1 [reference]	
2015	1.46 1.08-2.00)	<.001	1.15 (0.44-2.93)	.79	0.54 (0.23 - 1.22)	.15
2016	2.37 (1.79-3.17)	<.001	1.37 (0.52-3.51)	.55	1.62 (0.85 - 3.17)	.15
2017	2.99 (2.27-3.97)	<.001	0.43 (0.11-1.30)	.15	1.51 (0.78 - 3.01)	.23
2018	3.25 (2.47-4.32)	<.001	1.16 (0.44-2.96)	.76	2.01 (1.07-3.90)	.03
2019	3.54 (2.67-4.75)	<.001	0.39 (0.06-1.54)	.42	3.27 (1.76 - 6.35)	<.001
Interaction terms						
2015* Social	0.90 (0.50-1.66)	.74	1.18 (0.20-6.72)	.88	2.48 (0.44-15.38)	.30
2016* Social	0.57 (0.31-1.05)	.07	0.19 (0.01-1.66)	.19	0.51 (0.06-3.50)	.51
2017*Social	0.55 (0.31-0.98)	.05	1.85 (0.25-13.31)	.53	1.67 (0.39-8.87)	.50
2018* Social	0.66 (0.54-1.40)	.14	0.21 (0.01-1.88)	.21	1.17 (0.26-6.26)	.83
2019* Social	0.79 (0.45-1.43)	.46	1.19 (0.04-18.01)	.65	0.92 (0.17-5.28)	.95

Ns are not weighted. All models are adjusted for age, sex and region. Results for prevalence of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. p<0.005 p values are indicated in bold. *p<0.01, **p<0.001.

[a]Long-term (>1-year) ex-smokers. [b]Past year ex-smokers who did not use an e-cigarette in their most recent quit attempt; [c]Long-term ex-smokers who quit smoking before 2011;SEP = Socio-economic position; Other = higher SEP (mortgage bought, owned outright, private renting and other); Social housing = lower SEP ((local authority or housing association)

Table A6.2: Associations between e-cigarette use and SEP (housing tenure) stratified by year among i) long-term ex-smokers, ii) past-year ex-smokers and iii) pre-2011 long-term ex-smokers in England (2014-2019).

Year	**2014**	***P***	**2015**	***P***	**2016**	***P***	**2017**	***P***	**2018**	***P***	**2019**	***P***
Long term ex-smokers[a]	(N=3170)		(N=3462)		(N=3533)		(N=3617)		(N=3532)		(N=2528)	
SEP												
Other (N=12008)	1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]	
Social housing (N=7834)	2.31 (1.41-3.68)	<.001	1.99 (1.34-2.93)	<.001	1.27 (0.84-1.85)	.24	1.24 (0.88 - 1.71)	.21	1.46 (1.06 – 2.00)	.02	1.84 (1.28 - 2.59)	<.001
PY-ex-smokers[b]	(N=194)		(N=158)		(N=129)		(N=152)		(N=152)		(N=85)	
SEP												
Other (N=479)	1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]	
Social housing (N=391)	1.87 (0.55-5.68)	.30	(0.54-7.65)	.23	(0.02-2.05)	.33	(0.54-16.28)	.18	0.79 (0.04 – 5.24)	.84	3.07 (0.13 - 37.83)	.87
Pre-2011 LT ex-smokers[c]	(N=2683)		(N=2805)		(N=2703)		(N=2649)		(N=2501)		(N=1722)	
SEP												
Other (N=13105)	1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]		1 [reference]	
Social housing (N=1958)	1.11 (0.25-3.42)	.87	2.76 (0.73 - 8.67)	.10	0.58 (0.09 - 1.98)	.47	1.84 (0.71 - 4.24)	.20	1.64 (0.60-3.77)	.28	1.16 (0.34-3.04)	.72

Ns are not weighted. All models are adjusted for age, sex and region. Results for prevalence of e-cigarette use are presented as Odds Ratios (95% CI) against the indicated referent. p<0.005 p values are indicated in bold. *p<0.01, **p<0.001.

[a]Long-term (>1-year) ex-smokers. [b]Past year ex-smokers who did not use an e-cigarette in their most recent quit attempt; [c]Long-term ex-smokers who quit smoking before 2011;SEP = Socio-economic position; Other = higher SEP (mortgage bought, owned outright, private renting and other); Social housing = lower SEP ((local authority or housing association

Appendix 7 – Chapter 5 (Study 4) supplementary material

Table A7.1: Data saturation table including theme presence in each transcript.

Themes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Persisting with the e-cigarette	x	x	x	x	x				x
Switching for health and finances		x	x	x	x	x	x	x	x
Switching for family		x	x	x		x		x	x
A tool and/or a pleasure	x	x	x		x			x	x
E-cigarette partially reducing urges to smoke	x	x		x	x	x			x
Mental health disrupting quit attempt	x	x					x	x	x
Emerging themes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Stress and quitting smoking							x	x	x
Vaping identity	x							x	x

Figure A7.1: Study advert

EMA survey Items

Quantity and frequency of use (Every day in 'daily diary')
Did you use your e-cigarette today?

a) Yes
b) No

How many times did you use your e-cigarette today?

(Number scale)

How many puffs did you take on your e-cigarette today?

(Number scale)

How much e-liquid did you use today (approximately in millilitres)?

(Number scale)

How many puffs on the e-cigarette did you take in your most recent session?*

How many cigarettes have you smoked since your last session with the e-cigarette (or since waking up if this was your first session with the e-cigarette today)?*

a) 0
b) 1-5
c) 5-9
d) 10-14
e) 15+

*Randomly selected immediately after smart e-cigarette usage (not in daily diary)

Other items of interest

Tolerance (Randomly selected immediately after smart e-cigarette usage)

I feel like I need to use my e-cigarette more to get the desired effect

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

Perceived benefits (Randomly selected with daily diary)

Vaping helps me feel better if I have been feeling down
a) Strongly disagree

b) Disagree
c) Not sure
d) Agree
e) Strongly agree

Even when I feel good, vaping helps me feel better

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

Vaping helps me think better

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

Withdrawal symptoms (Randomly selected immediately before smart e-cigarette usage)

After not vaping for a while, I need to vape to avoid any discomfort

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

When I go too long without vaping, I feel impatient or irritable

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

Cravings/urges to use (Randomly selected in daily diary or immediately following smart e-cigarette usage)

How soon after waking up did you first puff on your e-cigarette?

a) 0 to 5 minutes
b) 6 to 15 minutes
c) 16 to 30 minutes
d) 31 to 60 minutes
e) 61+ minutes

f) Not applicable

When I have not vaped for a while, the craving gets intolerable

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

I crave e-cigarettes at certain times of the day

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

Keeping from smoking (Randomly selected in daily diary or immediately after smart e-cigarette usage)
How many cigarettes did you smoke today?

a) 0
b) 1-5
c) 5-9
d) 10-14
e) 15+

How helpful do you find e-cigarettes in enabling you to keep from smoking?

a) Not at all helpful
b) Slightly helpful
c) Somewhat helpful
d) Very helpful
e) Extremely helpful

Did you use the e-cigarette on an occasion where you would normally smoke?

a) Yes
b) No

Compared to tobacco cigarettes how satisfying is the e-cigarette?

a) Much less than usual
b) A little less than usual
c) The same as usual
d) A little more than usual
e) Much more than usual

Relative harm (Randomly selected in daily diary or immediately after smart e-cigarette usage)

Compared with cigarettes, how harmful are e-cigarettes to a person's health?

a) Much less harmful than cigarettes
b) Somewhat less harmful than cigarettes
c) About the same harm as cigarettes
d) Somewhat more harmful than cigarettes
e) Much more harmful than cigarettes
f) I don't know

Do you think e-cigarettes are addictive?

a) No, absolutely not
b) Yes, but they are less addictive than tobacco cigarettes
c) Yes, they are as addictive as tobacco cigarettes
d) Yes they are more addictive than tobacco cigarettes

Use despite harm (Randomly selected in daily diary or immediately after smart e-cigarette usage)

I use the e-cigarette despite disapproval or conflict with my friends or family

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

I experience negative physical or psychological consequences from vaping

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

Automaticity (Randomly selected immediately after smart e-cigarette usage)

I find myself vaping without deciding to

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

I find myself reaching for e-cigarettes without thinking about it

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

Sensory dependence (Randomly selected in daily diary or immediately following smart e-cigarette usage)

How pleasant is the e-cigarette to use?

a) Not at all pleasant
b) Slightly pleasant
c) Somewhat pleasant
d) Very pleasant
e) Extremely pleasant

I enjoy the feel of inhaling vapour into my mouth

a) Not at all enjoyable
b) Slightly enjoyable
c) Somewhat enjoyable
d) Very enjoyable
e) Extremely enjoyable

I like the feeling of creating vapour clouds

a) Strongly disagree
b) Disagree
c) Not sure
d) Agree
e) Strongly agree

Interview topic guide

Using the conceptual framework of PRIME theory, this smart e-cigarette study interview topic guide aims to explore aspects related to smokers' motivation to use an e-cigarette in a quit attempt. There will be focus on plans to continue to use an e-cigarette or make a quit attempt with an e-cigarette in future, evaluative beliefs about e-cigarette and conventional cigarette use and quitting smoking.

PRIME construct	Definition

Plans	Self-conscious intentions to continue to use e-cigarette (if abstinent) or to use e-cigarette again in future quit attempt.
Impulses	Urges to use e-cigarette during the day.
Motives	Wants (anticipated pleasure or satisfaction) and needs (anticipated relief from discomfort) of e-cigarette use.
Evaluations	Beliefs about e-cigarette use, smoking and quitting smoking with an e-cigarette.
Internal stimuli	Drives (nicotine hunger) and emotional states (pleasure and discomfort) related to e-cigarette use.
External stimuli	Other people using e-cigarettes. Available information on e-cigarettes.

Introduction
Thank you very much for agreeing to speak to me today.
Just to remind you, the purpose if this interview is to ask about your experience and thoughts on the e-cigarette you have been using over the past couple of weeks.
As a reminder everything you say will be anonymised and treated confidentially. Feel free to skip over any questions you don't wish to answer or to end the interview at any point.
The interview will be audio-recorded, and once it has been transcribed keeping your identity anonymous, the audio recording will be deleted. Is this ok with you?
This interview will be conducted in three parts. First I want to quickly ask you a couple of questions about you and how you've got on with your quit attempt. Then I will move on and ask you a bit about what you think about using an e-cigarette in a quit attempt. Finally I will ask you a bit about how using an e-cigarette fits in with your previous smoking behaviour and identity.

	Questions
Intro	Tell me a bit about you and your smoking. How long had you been smoking before this recent quit attempt? How much did or do you smoke? What kind of cigarettes do you smoke?
Plans	How has the quit attempt with the e-cigarette gone? Have you used an e-cigarette in a quit attempt before?

	(If abstinent) do you think you'll continue to use an e-cigarette going forward, and why? Do you plan on stopping? If so, why? If you didn't manage to quit successfully in this attempt, will you try again soon or in future? Do you think you'll try an e-cigarette again to quit smoking in future? If so/not, why?
Impulses	Did you experience any kinds of urges to vape during the day at times when you weren't able to? Could you describe these to me? When do these occur? If so, were these similar to the urges you have when smoking?
Motives	Does vaping give you any satisfaction or pleasure? In what way? Would you say that during the day, you look forward to vaping? Is this similar feeling to that you get when smoking? Probe > any motivation to vape because of anticipated pleasure or satisfaction that you knew it would give you? Could you expand on that? Does vaping relieve any discomfort for you? If so/if not are you able to describe it at all?
Evaluations	What are your thoughts on the e-cigarette as a tool to help you quit smoking? How has your experience of e-cigarette use over the past two weeks been? Enjoyable/unpleasant? Could you expand on what specifically you liked/didn't like? Do you think your views on vaping to quit smoking has changed at all since you started vaping last week?

Perceived health effects	What do you know about the health effects of e-cigarettes? And compared with smoking? Where did you get your knowledge about e-cigarettes and potential health effects? Newspapers, GP, TV, friends etc?
External stimuli	Are there any reasons that you think influenced you making a quit attempt? Are there any reasons that perhaps influenced trying the e-cigarette in this quit attempt? For instance could you describe any external influences to vaping? Could be other people, media etc…

Construct	Questions
Family responsibility	Do you have any family/friends that you live with or see regularly at the moment? Is there anyone who has influenced your quit attempt (friends/family? How have they influenced you? What do your family or close friends think about using an e-cigarette in a smoking quit attempt? What do they think about e-cigarette use in general? Has a feeling of responsibility to yourself or others influenced your quit attempt? How so?
Smoking identity	How did you start smoking? Did you smoke with the same people since you started smoking? How has smoking shaped who you are and what you do? Do you think you developed a ‘smoking identity’? I.e. you see yourself as a smoker and other people see you as a smoker. Do you think that using an e-cigarette has a certain identity attached to it and why?

	Does using an e-cigarette change any kind of smoking identity, if you think you had one? How would using an e-cigarette in future change how you interact with smokers (if you decide to vape on an occasion when you would normally be smoking)?
Sociable hedonism (recreational use)	Do you think there was an element of risk-taking or rule-breaking excitement when you first started smoking? Has this changed at all the longer you have been smoking? How do you see e-cigarettes in that sense, is there anything about them that is similar to the risk-taking of smoking? Is the e-cigarette something just to help you stop smoking? Or do you see the e-cigarette as something for pleasure and enjoyment? How so? Do you still socialise with other smokers? Have e-cigarettes changed this relationship at all or do you think they might in future? How?

Calculation of Cohen's kappa (k) for inter-measure (EMA vs smart e-cigarette reliability)

<u>EMA daily diary vs Gram or JUUL</u>

Self-reported EMA daily session data vs SEC puff data

Let p_{ii} indicate the proportion of responses classified into category *i* according to both measures. The sum of these proportions is called the proportion of observed agreement, which is given by:

$P_o = \sum p_{ii}$

For the available data from P1, P4, P6 and P7:

$P_o = 0.23 + 0.08 + 0 + 0 = 0.31$

Furthermore, let p_{i+} and p_{+i} indicate the proportion of responses classified into category i by the SEC and EMA measure, respectively. The numbers p_{i+} and p_{+i} are the base rates, reflecting how often each measure used category i. Using these base numbers, the proportion of expected agreement is given by:

$P_e = \sum p_i + p_{+i}$

P_e = (0.27 x 0.65) + (0.58 x 0.12) + (0.08 x 0.15) + (0 x 0) + (0 x 0.08) = 0.25

Finally, the kappa statistic can be defined as a function of the observed and expected agreement, given by

$k = P_o - P_e / 1 - P_e$

Therefore

k = (0.31 - 0.25) / 1 - 0.25
k = 0.07

<u>EMA most recent session puff vs SEC</u>

Self-reported EMA puff data vs SEC puff data

Let p_{ii} indicate the proportion of responses classified into category i according to both measures. The sum of these proportions is called the proportion of observed agreement, which is given by:

$P_o = \sum p_{ii}$

For P1, P4 and P6 data:

P_o =0.14 + 0.16 + 0.01 + 0.07 = 0.38

Furthermore, let p_{i+} and p_{+i} indicate the proportion of responses classified into category i by the SEC and EMA measure, respectively. The numbers p_{i+} and p_{+i} are the base rates, reflecting how often each measure used category i. Using these base numbers, the proportion of expected agreement is given by:

$P_e = \sum p_i + p_{+i}$

P_e = (0.30 x 0.19) + (0.53 x 0.26) + (0.11 x 0.04) + (0.07 x 0.51) = 0.23

Finally, the kappa statistic can be defined as a function of the observed and expected agreement, given by

$k = P_o - P_e / 1 - P_e$

Therefore

$k = (0.38 - 0.23) / 1 - 0.23$
$k = 0.19$

Chapter 5 interview coding matrix

PRIME domain	Theme	Quotes
Plans	Persisting with the e-cigarette	*"Yes, if it's an effective device. I found I had to go back on to tobacco from Saturday, but I slightly lost the taste for it, so I only need the odd one. Whereas before, with the other e-cigarettes I've tried, I'd use it then think, I really need a cigarette. From Saturday, I wish the e-cigarette was working because I would like to have had that instead of the cigarette."* [P1] *"I will continue with the e-cigarette as long as I need cigarettes, nicotine. At this moment I'm thinking I'm not going to end it very soon, the e-cigarette, the vape cigarette, because I am enjoying it and it's very good for me. No problem for me, and good as it goes. And maybe in the future I might stop it if I get help from the smoking clinic. If I get help, I'll stop it maybe."*[P2] *"Because I think it's better than smoking actual cigarettes. It's said that tobacco smoke contains over 70 substances known to cause cancer. Then there's other public health warnings also attached to smoking. So, I do believe that the vape is far more beneficial."*[P3] *"Yes, definitely, because that[e-cigarette] is a substitute that's very easy to use."* [P4] *"Yes, most certainly. So, I'd normally have about five [cigarettes] or so in a*

		whole evening of three hours. So, driving, I feel the need to smoke, I guess. But I just have my vape now, which has soothed it." [P5] *"I'm going to give it a good go. Because I meant to give up smoking, I want to give up smoking. I don't want to be smoking anything really. I've been very successful using the patches in the past, so, I don't know, we'll see."* [P6] *"I will continue, definitely. I have to, but this has really helped. The whole thing about it is that it did help."* [P9]
Evaluations	Switching for health and finances	*"You feel stronger after you take the e-cigarette, not cigarette. Cigarette makes you weaker. This one makes you quite normal. It keeps your normal oxygen level."* [P2] *"To save money, and for my health reasons, to save myself from any harm. And another one, to save money a little bit. I can save and I can do something else. Financial reason."* [P2] *"I presume the fact that sooner or later, I'm going to have to lose all my teeth due to smoking. That my finger are red from smoking. My heavy breathing. I do a lot of sport, therefore, in some way it hides the fact that I'm a heavy smoker. If you see me in my speedo and you say "wow, he's a fit guy". You don't realise that I smoke 60 cigarettes a day."* [P4] *"I can see why it [the e-cigarette] would be less harmful than smoking, because somehow I don't cough so much. I cough quite a bit from smoking."* [P5] *With the state of my lungs, basically, I've got emphysema. I notice I start to cough more when I'm smoking cigarettes and I don't want to end up with lung cancer.* [P7]

		"You feel stronger after you take the e-cigarette, not cigarette. Cigarette makes you weaker. This one makes you quite normal. It keeps your normal oxygen level." [P2] *"Financial and for my health. I can see within a week of stopping smoking, my skin looks clearer and things like that. Yes, for my health, absolutely. The smell doesn't linger and all those things, ashtrays."* [P6] *"I'm a good swimmer and I haven't been good for the last couple of years, but I haven't been going. Since last week I've been back to the swimming. I found it hard for the first ten feet or for the first ten metres to swim with the smoking, and the next day without smoking it's different, you feel different. Whoever smoked, that's who will believe it, will see the difference."* [P9] *"From the point of view of having a cigarette and then thinking, I didn't really need it. Not so much from the fact that's another nail in the coffin. It's just that's a waste of time and money almost. Certainly not from health reasons. I'm no spring chicken. No family. We've all got to go at some stage."* [P1] *"It's just the health is the most important thing, my health. I'm not young anymore, I'm not a spring chicken, we're growing old. It does affect your health big time, and the switch to vape is a good idea."* [P9]
	Switching for family	*They're happy, I guess. Even the smoking friends have been happy that I've gone off it.* [P6] *"Oh boy, my mum. My mum suffers from lung cancer and she doesn't smoke all her life. She never smoked, she never*

		drank, and sometimes, the last couple of days or the last week she sees me, she's really pleased. They're supporting that, definitely." [P9] *"My family prefer that I use these [e-cigarettes] as opposed to smoking cigarettes, so most definitely, yes. The ashtrays and the smell and all those health indications. So, for my son and for me health wise."* [P6] *"Yes, because of my family, I stopped [smoking]. For this reason. For this particular reason. Because they are not happy with me. They are more worried because anything might happen to me. That's why I thought, I might as well make a change to my lifestyle, go to e-cigarette and it will be better for me to change everything in my life."* *"I've just been through a really difficult time with death and dying. It wakes you up, makes you say, I've just finished caring for a very ill person, the last thing I want to do now is get sick myself. I'm saying the same thing with Sam, it's like now is our chance to live, so let's live."* [P8]
	A tool and a pleasure	*"It's got two elements. I would say both to some. I'd say both, myself, personally."* [P3] *"One concern I would have is if you hit the sweet spot are you ever going to get off the vape, so that would be a concern for me. That's one reason I don't really want to enjoy it."* [P8] *"No, I don't think so, it has to be for a reason. It's nothing to enjoy."* [P9] *"I think the two are interlinked really. It's certainly to cut down and possibly to cut out the cigarettes altogether. You use these cigarettes or devices for enjoyment. If you didn't use them, you wouldn't be enjoying things quite as*

		much. Not so much not enjoying things but you'd find life more difficult, definitely if you've been addicted to nicotine, and you can't stop through other means. I think I'll always be addicted to nicotine." [P1] *"It's not just about stopping smoking. It's for pleasure as well, excitement, and a better experience. And the quality, the looks, the device. So, it's everything I'm looking to it, into this vape lifestyle. So, it's a very pleasurable experience. And it's a very quality lifestyle, smoking vape. It's very quality."* [P2] *"Just the sensation of smoking, I think it is. Because I like smoking, I just don't like the effects it has, unfortunately. When I have the vape, the impulse to go out and buy a cigarette or to go out and buy a deck of cigarettes is evaporated or eliminated."* [P5] *"Maybe it relieved a little bit of discomfort, but I didn't get the same satisfaction, like a cigarette does, no."* [P6] *"Not really pleasurable, no. My friend, he really likes to blow those big clouds of smoke, and I just want the pain to go away."* [P8] *Yes, I will say so. I don't know if my brain reacts the same way because of the chemical inside, if it's... I feel like I'm speaking to you with... And if I had... It would be the similar feeling if I had a real cigarette."* [P4]
Motives	Urges to smoke	*"I've found with vaping you're doing it constantly. If you can, you're taking puffs on a fairly constant basis. If you're just walking along the street, you're using it quite regularly. Whereas, with a cigarette, you would stop and go for a while. It's probably because it's a stronger, quicker hit.*

		Whereas, with vaping, you need to do it constantly to have that satisfaction." [P1] *"Not really because when you get the urge for a cigarette, it's a strong urge. Whereas, I think when you get an urge to vape, it's less strong probably because the effect of the vape is less satisfying."* [P1] *"I don't really have any discomfort. I wouldn't classify it as discomfort, it's just a slight urge to smoke, and sometimes it does help to stop it slightly, yes, for a time."* [P7] "*Instead of having cigarette, I do e-cigarette to keep my craving and to tell me brain that it's a cigarette, end of the day, to recover from the cigarette, and use e-cigarette"* [P2]. *"It's difficult to say. I'm still smoking about roughly the same, perhaps one less, but it doesn't really satisfy the urge to smoke, it doesn't stop you wanting to smoke."* [P7] *"In the mornings I try to avoid, even with the slight urges I try to stop it. I try to vape, which puts it off for about half an hour or so, and then I still want to smoke a cigarette."* [P7]
Internal stimuli	Mental health	*"I don't know. Like I said to you, recently, I've been under a lot of stress. Or in some way, it's a habit that has been when I got stress, I will roll a cigarette or roll a joint. Now, I am not sure that the vaping will compensate. But if one is in a stable mind or maybe more happy, I think one can actually... I could." [P4]* *"I have the same feeling. I don't know... Again, I don't know, but my stress levels seem to be reduced more by rolling tobacco and smoking a tobacco. Maybe I get more nicotine, I don't know exactly*

		how it work, but… Like yesterday, I was very stressed, so the e-cigarette did not do it for me." [P4] *"Then I wasn't even sure if it would be possible to smoke. I thought two days or so of not having had any, particularly at the moment, which is a difficult time. I would have liked to have said, right, let's just try and bite the bullet but it wouldn't have been feasible."* [P1] *"It did in the beginning, but I don't think that was fair because in the beginning I was also smoking cigarettes now and again, so I could say the last three days I'm feeling really uncomfortable, and just now, it [the e-cigarette] didn't help."* [P8] *"No, I started as a young kid. The stress I've been through and the stress I was going through when I came to this country as well, suffering from stress disorder. Nothing numbed my brain but the smoking. I'm still on medication till now because of that, but the cigarette is just the first thing you inhale, and it's really hard and it did help numb my pain, but for a short time, not for a long time."* [P9]

Gram user complaints

Participant quote
"Yes, it went well. I think from the actual quit attempt date, until it stopped working. I saw you on the Tuesday and quit on the Saturday. I think I had two cigarettes the next day and then maybe one the following day, and then that was it, so it was doing the job." [P1] "It will have been a couple of weeks ago. I explained to you, the vape that you gave me, basically, it started malfunctioning after a couple of weeks. That would have been around the time that I thought, I wish this vape was working properly. I tried it on the phone and it was doing nothing." [P3] Sadly, recently, I spent some time in my bed with my computer and I don't have the plug, therefore, it was not plugged in. I will say that... I believe that I could swop cigarette for vaping if it's there every time. [P4]

"The only problem sometimes with the vape, once it went off and I didn't realise it was in my pocket. It was in my pocket, I knew it, but I didn't realise that for some reason, I think there was something wrong with the technology of it, but it was as if I was taking a giant breath on it, and it was smoking itself. And it was boiling hot, so I don't know how long it had been in my pocket for. And the liquid part was empty, so it was just vaping itself." [P5]

Appendix 8 – Chapter 6 (Study 5) supplementary material

TFA construct	Questions
Intro Psychological capability (COM-B)	Tell me a little about you and your smoking. - How long have you been smoking for before this most recent quit attempt? - How much do/did you smoke? - What drove you to seek SSS support? And how did you get on with your quit attempt? - Had you made attempts to quit in the past? - How did you go about it? - How did they go? Had you used or thought about using an e-cig as part of your quit attempt before? Did you have any knowledge of e-cigarettes before being offered one by your advisor? What did you know?
Affective attitude Reflective motivation (COM-B) Psychological capability Intervention coherence	Was going to your SSS to quit smoking something that you were happy to do? - Did it fit with how you would want to quit smoking? What about other types of support you received (e.g. Champix/ advice from advisors)? What about other types of support you received (e.g. champix/ advice from advisors)? - Did you like/dislike using the Champix and attending the support from advisors? - Could you expand on why you did/didn't like given part? What are your thoughts about using an e-cigarette to quit smoking? - Did you like or enjoy using an e-cig? - What in particular did you like? - What in particular did you dislike? Did all this support you received make sense to you? (INTERVENTION COHERENCE)
Burden Physical Capability (COM-B)	How did you use the e-cigarette as part of your quit attempt? - How easy or difficult was it to use it to use the e-cig in your quit attempt? How easy/difficult did you find it to actually use the e-cigarette- i.e. refill/replace coil, set it up, puff technique etc?

Automatic motivation Physical Capability Physical opportunity	Did you develop a routine at all for using your e-cig? - Can you talk me through this? - I.e. certain times of day, locations). - How does this reflect your previous smoking routine? Were there any physical difficulties you experienced? If so please explain. - How did it make you feel? Any side effects? Any relief? What about the Champix and support from your advisor? - Did you feel it was an extra burden with all three parts together? How so? How easy/hard was it to attend your sessions with your advisor? Could you expand on that? Did it work with your day to day work/life?
Ethicality	What do you think about being offered an e-cig by your stop smoking advisor or being given in the context of the other support you received? - Did you think it was a good/bad thing? - Did you think it was appropriate/ fair to offer e-cigs via a health service? Rather than a shop? Were you initially interested/disinterested and if so, why? What are your thoughts on receiving medicine to help you quit?
Intervention coherence Perceived effectiveness	Did you understand the support package you received and how it worked? - What is your understanding of the purpose of the e-cigarette? - What is your understanding of the purpose of Champix and support from your advisor in your quit attempt? To what extent do you think e-cigs can help smokers to quit? - And what about the Champix and behavioural support? - Can you talk me through this? Did the offer of the e-cigarette change how effective you thought your support from your advisor and the Champix was? - i.e. Being offered an e-cig might imply that the rest of the support isn't good enough on its own?

Opportunity costs	What were the pros/advantages of using the e-cig to try and quit? If any? What about the downsides? Do pros outweigh the cons?
	Did using the e-cigarette change in any way the time you spent at home or at work?
Social opportunity (COM-B)	How did using the e-cigarette fit within your social life and any previous social smoking?
Social opportunity	Do you know other people around you who use e-cigs?
Social opportunity	How did those around you (family, friends, and colleagues) react to the e-cig? Were they supportive? *(Prompt to pick up any potential stigma?)*
Social opportunity	How did your family/friends react to you making a supported quit attempt with your SSS? (*Prompt to pick up any potential stigma?)*
Social opportunity	If you engaged with the vaping community, how did you do this and what was your experience?
	Was there anything else that you had to give up or change in order to use the e-cigarette?
Perceived effectiveness	How effective do you think the Champix and support from your advisor were to help you try and quit smoking? How effective do you think having an e-cigarette was at helping you quit?
Self-efficacy	Did you have confidence that you could quit smoking? - Do you think you still could have managed to quit with just the e-cig and not Champix/ support? - And vice versa? If yes/no, why do you think this was the case/can you talk me through this?
Withdrawal symptoms	Do you feel like you could maintain with an e-cigarette? Or would you not need it anymore

TFA construct	Questions
Intro	Tell me a little about you and your smoking. - How long have you been smoking for before this most recent quit attempt? - How much do/did you smoke? - What drove you to seek SSS support? And how did you get on with your quit attempt? - Had you made attempts to quit in the past? - How did you go about it? - How did they go? Had you used or thought about using an e-cig as part of your quit attempt before?
Psychological capability (COM-B)	Did you have any knowledge of e-cigarettes before being offered one by your advisor? What did you know?
Affective attitude	Was going to your SSS to quit smoking something that you were happy to do? - Did it fit with how you would want to quit smoking?
Reflective motivation (COM-B) Psychological capability	What about other types of support you received (e.g. Champix/ advice from advisors)? What about other types of support you received (e.g. champix/ advice from advisors)? - Did you like/dislike using the Champix and attending the support from advisors? - Could you expand on why you did/didn’t like given part? What are your thoughts about using an e-cigarette to quit smoking? - Did you like or enjoy using an e-cig? - What in particular did you like? - What in particular did you dislike?
Intervention coherence	Did all this support you received make sense to you? (INTERVENTION COHERENCE)
Burden	How did you use the e-cigarette as part of your quit attempt? - How easy or difficult was it to use it to use the e-cig in your quit attempt?
Physical Capability (COM-B)	How easy/difficult did you find it to actually use the e-cigarette- i.e. refill/replace coil, set it up, puff technique etc?

Automatic motivation Physical Capability Physical opportunity	Did you develop a routine at all for using your e-cig? - Can you talk me through this? - I.e. certain times of day, locations). - How does this reflect your previous smoking routine? Were there any physical difficulties you experienced? If so please explain. - How did it make you feel? Any side effects? Any relief? What about the Champix and support from your advisor? - Did you feel it was an extra burden with all three parts together? How so? How easy/hard was it to attend your sessions with your advisor? Could you expand on that? Did it work with your day to day work/life?
Ethicality	What do you think about being offered an e-cig by your stop smoking advisor or being given in the context of the other support you received? - Did you think it was a good/bad thing? - Did you think it was appropriate/ fair to offer e-cigs via a health service? Rather than a shop? Were you initially interested/disinterested and if so, why? What are your thoughts on receiving medicine to help you quit?
Intervention coherence Perceived effectiveness	Did you understand the support package you received and how it worked? - What is your understanding of the purpose of the e-cigarette? - What is your understanding of the purpose of Champix and support from your advisor in your quit attempt? To what extent do you think e-cigs can help smokers to quit? - And what about the Champix and behavioural support? - Can you talk me through this? Did the offer of the e-cigarette change how effective you thought your support from your advisor and the Champix was? - i.e. Being offered an e-cig might imply that the rest of the support isn't good enough on its own?

Opportunity costs Social opportunity (COM-B) Social opportunity Social opportunity Social opportunity Social opportunity	What were the pros/advantages of using the e-cig to try and quit? If any? What about the downsides? Do pros outweigh the cons? Did using the e-cigarette change in any way the time you spent at home or at work? How did using the e-cigarette fit within your social life and any previous social smoking? Do you know other people around you who use e-cigs? How did those around you (family, friends, and colleagues) react to the e-cig? Were they supportive? *(Prompt to pick up any potential stigma?)* How did your family/friends react to you making a supported quit attempt with your SSS? (*Prompt to pick up any potential stigma?)* If you engaged with the vaping community, how did you do this and what was your experience? Was there anything else that you had to give up or change in order to use the e-cigarette?
Perceived effectiveness	How effective do you think the Champix and support from your advisor were to help you try and quit smoking? How effective do you think having an e-cigarette was at helping you quit?
Self-efficacy **Withdrawal symptoms**	Did you have confidence that you could quit smoking? - Do you think you still could have managed to quit with just the e-cig and not Champix/ support? - And vice versa? If yes/no, why do you think this was the case/can you talk me through this? Do you feel like you could maintain with an e-cigarette? Or would you not need it anymore

Mechanisms of change (COM-B) topic guide

COM-B	What needs to happen for the target behaviour to occur?	TFA overlap	Questions
Physical capability	Having the physical skills to use the e-cigarette as part of the intervention package	Burden	ASKED IN TFA - BURDEN
Psychological capability	Having the knowledge and capacity to use e-cigarette alongside usual care.	Intervention coherence, self-efficacy, burden	ASKED IN TFA - INTRO
Physical opportunity	Environmental Factors that enable e-cigarette use.		Were you able to use your e-cigarette at times when you would have otherwise smoked? What is the availability of e-cigarettes and e-liquid where you live/work? Are there vape shops? How did you find and buy e-liquid? Online? In vape shops? Do you think the e-cigarettes are affordable? Compared with smoking cigarettes?
Social opportunity	Social Factors that enable or prompt e-cigarette use	Opportunity costs	ASKED IN TFA – OPPORTUNITY COSTS
Reflective motivation	Self-conscious decision making and reasoning that influence e-cigarette use.	Perceived effectiveness, affective attitude, opportunity costs, ethicality	How likely are you to continue to use an e-cig in future?
Automatic motivation	Feelings and impulses that affect use of the e-cigarette intervention.		How did the support (Champix and behavioural support)

			help you cope with urges to smoke during the quit attempt? To what extent did e-cigs help you cope with urges to smoke during your quit attempt? Do you still experience the same kinds of urges to smoke that you had previously? Do you feel capable of maintaining your quit attempt with an e-cigarette? Or do you not need to use it anymore? Did you have any worries or concerns about using an e-cig?)

Data saturation table – Chapter 6. Including theme presence in each transcript, with data saturation achieved by Participant 10.

Theme	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Positive affect for advisor	x	x	x	x	x	x	x	x	x	x
Difficulties with SSS care pathway	x	x			x	x	x	x	x	x
Side effects from Champix	x		x	x	x				x	
Harshness of puffing		x	x	x	x			x		
E-cigarette replaces one addiction with another	x	x	x	x	x	x			x	x
Divergence of opinion on providing e-cigarette as part of SSS offering	x	x		x	x		x	x	x	x
Complementary nature of intervention package	x	x	x	x	x	x	x	x	x	x
Champix effectively reduces urges to smoke		x	x		x	x		x		
Replacing the habit of smoking		x	x	x	x	x		x	x	x
E-cigarette as a back-up in the quit attempt	x	x	x	x	x			x		x
E-cigarette as a short-term tool to quit smoking		x			x		x			x
Cost-saving	x	x	x	x	x	x	x	x		
Opportunities to vape	x	x	x	x	x		x			
Family support to quit smoking		x		x	x	x		x		x

Chapter 6 TFA and COM-B theme coding framework

TFA/COM-B Domain	Theme	Frequency (No of Participants)	Barrier (B) Enabler (E) Mixed (M]	Example quotes
Affective attitude	Positive affect for advisor	10	E	I mean, we have a good chat. Yeah, he's direct, very supportive. I get that [SSS advisor] cares when he looks you in the eye to stress a point. You know, that's the thing when you talk to people when they look you in the eyes of stress of point and I get that from him. [P5, M] [SSS advisor] was really good. She encouraged me to obviously carry on quit smoking. I was doing a really good job, I had stopped smoking, and her support, cheering me on every fortnight, it was the intention not let her down as well. [P7, M] [SSS advisor] talks to you like she knows exactly what she’s going on about and the dips and the highs and the lows. [P9, F] I mean we know he's there when we need it. If we need him, he always says that we can text or ring, if we're struggling and have problems. [P3, M]
Burden	Difficulty with SSS pathway	8	B	When I rung them and they said, oh, you've got to go to this appointment and you've got to do this and that, I thought, really? It sounded like no one was making it easy to give up smoking. Because I work full-time, so I've got to go to meet somebody, you get a bit of paper, to go back to my doctor, to go from my doctor to the chemist within 48 hours, you just think, why can't I just go straight to my doctor and get the prescription? [P9, F]

				It's every week, once a week, and then I've got baby, so I have to walk up there. We walked up there, and it was pouring with rain the other day. I missed one because I just couldn't get up there. I don't drive, I live on the second floor. If I'm out I have to rush back and get a bus, so it is a chore to have to go. [P10, F] Picking up a prescription from the from the boots chemist, you know. I had to text [SSS advisor] last Sunday. My wife put the letter in at the doctors on Wednesday. Given that [SSS advisor] gave me the letter on a Monday, but that was my fault. I had less than what I thought I had. Picking it up at boots on a Sunday, when the woman was on her own and she had a queue. And it was issued from the doctors to the pharmacy. So I text [SSS advisor] when I was there, trying to get it because I was getting rather stressed. Which would have been a trigger for me to start smoking again, I ended up walking away with no medication. [P5, M]
	Side-effects from Champix	5		I felt sometimes I get a sick feeling. But that's early in the morning. I don't know if that's because I haven't eaten anything. But definitely if you cheat you do feel rough as hell, normally. I've done that a few times, I've cheated, and you do regret it. [P1, M] I must admit they do make me nauseous. I'm not taking two a day. I can't. They make me feel quite sick. And on the odd occasion I have been sick. So, I'm just taking one a day. [SSS advisor] is actually, this next prescription or the last prescription I had, he's reduced the milligram down, so I'll be able to take the two a day. Yeah. Because I can't. It makes me feel so ill, truly. [P3, W]

				It depends. Sometimes it makes you feel sick. Sometimes you can't sleep. [P4, W]
Ethicality	E-cigarette replaces one addiction with another.	8	B/M	B - But what you're doing is giving someone who is addicted to nicotine, nicotine, which I don't understand. Am I happy that doctors prescribe nicotine to smokers? The answer would be no. [P9, W] M - I just don't know, if it's like my mum's doing the Nicorette for years and gave up smoking for years, so it's like [the e-cigarette is] literally substituting it, it's not really getting rid of that habit or addiction. [P10, F] M - To be truthful I mean I've smoked for so many years, it's sort of inbred, it's me. Everyone knows, I mean they can't believe I'm giving up smoking again. But I don't wanna be a non-smoker but then a vape addict. [P4, F]
	Divergence of opinion on offering e-cigarette as part of SSS offering	8	Supportive of offering ECs at SSS (+) Against offering ECs at SSS (-)	(+) I think it does depend on the individual. Because it's not for everyone. People have their reservations. You know, whether it's a little bit of bad press that one blew up. There are many different flavours. I think it depends on the individual. But being that I have now got the hindsight that I've used it and it's helped. I'd say give it to everyone. Offer it for everyone. Not give it. Offer it to everyone. It's your choice. It does help. [P5, M] (+) It's a good thing because it's helped me stop, so it would help other people stop. Especially the some of the younger generation that are trying to get off cigarettes and stuff, as e-cigs are so trendy

				now, so get so many flavours out there, it will help a lot of the younger generation break free from smoking. [P7, M] (+) If it's gonna help you pack up, like I said the first two or three weeks, or four weeks, then I think it's a good idea. [P2, M] (-) Well, probably yeah, I think people would not necessarily get them for free. I probably don't agree with that because they only cost 10-15 quid and you're gonna save that in what you're not smoking anyway ain't you easy. [P1, M] (-) But I don't understand why it should be on prescription, because I'm not being funny, it's still a drug, and if you're going to bar cigarettes or put taxes up, why should you give a smoker an e-cigarette, because they'll get addicted to that as much as they have fags. [P9, F] (-) Probably not, because if you want this, they are not expensive are they, and if you're saving all that money on cigarettes, then you can afford to buy one. I mean if this break, I'd go get myself another one the same. [P4, F]
Intervention coherence	Complementary nature of intervention package	10		The vape is quite physical, and then the Champix is the craving, and obviously the support is to keep you encouraged, to carry on, to help you feel encouraged. [P10, F] At times, when I took Champix, I don't know what it is about it but as you are smoking with them you don't know but you are gradually reducing your cigarettes, and you get to a point of packing up

				without really knowing. It’s weird, and I’ve tried to explain it to friends who smoke. The e-cigarette is another device that you could use, because, a bit like putting on a patch as well, if you get the craving and you’re going to use an e-cigarette as another deterrent not to cheat. [P1, M] Coz it takes it off, even once the Champix is finished, I think it will take the edge off. And you won't be so worried about, oh I've got no tablets now. They say the 14 weeks or 16 weeks. Even though it’s all out of your system within those few months, if you're a long-term smoker or a really heavy smoker, you're still gonna be thinking about it after. [P4, F] It's that same sense with the vape stick. It's there as a backup to the tablets and as I said. I think I'm quite lucky where it was a yes in the envelope and I've got one because I think it definitely helped with the tablets. Knowing that there is someone at the end of the phone that I could text or call if I need to for a little bit of a kick. It's like a triple threat as such - for me not smoking again. [P5, M] Yes, it did, very much so. The Champex is the blocking thing, which has worked. Kel does give me the support I needed, which gave me the encouragement I needed when I was like what am I doing this for, sort of thing. The e-cigarette is like a backup. You get to the point where you go I just want a cigarette, I'm just going to have one, but, no, I’ll have this instead. It's just that last little bit that you needed to finish it off, so they work really well together. [P6, M]

Perceived effectiveness	Champix reduces urges to smoke	7		The urges, they slowly go within the first three weeks. They get less and less. And you don’t want a cigarette. [P2, M] My understanding is on a personal level, what I think is really striking to me is that it stops the receptor. It stops the receptors in your brain. And it stops that feeling dead. I don't know what it does in the brain. with the receptors and the messages that get sent from your synapses that says that you want a cigarette. I don't know what it does up there but it's definitely doing something. And it's stopped me wanting a cigarette, it stopped that urge. [P5, M] It's a lot easier with the Champix and the counselling, because when I had the patches, it didn't seem to do anything. I was constantly craving for a cigarette, whereas with the Champix I don’t crave it, I just fancy it. It's not where I've got to have it and I'm going to do anything to get it, it's just, oh, I fancy a cigarette. [P8, F]

Automatic motivation	Replacing the habit of smoking (E-cigarettes effectively substituting cigarettes)	8	E	The pros [of using an e-cigarette], it's just trying to break the habit of that cigarette from hand to mouth. Yeah with me it's just that habit. [P3, F] Sometimes, smoking is a habit, well it is a habit, well not having a cigarette but just a puff on that [e-cigarette] will curb it. Just because you're doing something with your hands. [P4, F] Sucking an e-cigarette, it mimics what you would do if you were having a cigarette. So in that respect, yes, but for the taste and all the rest of it, no. [P6, M] I know it's helped some people to give up smoking, but as they said, all it did was keep their habit going a bit longer because they had to get over the fact they weren't holding a cigarette. [P8, F] Yeah because it takes that urge, that urgency to light a cigarette up. You'll have a go on that before you light an e-cigarette up. [P2, M] I've still got it there, as a, not a substitute, but I'm still using it. I suppose it is a substitute, but it's there and I'm not worried about cigarettes, I've got that. [P4, F] It does work because the only time I really think about having a fag now is after I've had something to eat, but then I'll have a couple of puffs of the vape and then go put it back and I'm fine. [P8, F]

Reflective motivation	E-cigarette is a back-up in quit attempt	7	E/M	E - The EC is like a backup. That's how I use them anyway, I don't use them all the time. But on days when you are quitting and you feel the craving. [P1, M] E - So, but I'm not on it all the time, like I was with cigarettes. It just, it's slotted in well, but it's not taken over as a replacement of the cigarettes. It's just -- if you need it. [P4, F] M - With the vape if you're in a stressful situation it's beneficial to have something there. If you're used to doing that you can replace it with something more healthy, great, like exercise or something if you have the time, but if you can't it is great in that sense. [P10, F]
	E-cigarette as a short-term tool to quit smoking	6	M	M - Well, I think for the first two or three weeks that e-cigarette would be ok. But once you get into the other weeks, I think you could slowly drop that and wipe it out altogether. [P2, M] M - I'll probably wean myself off of it, because I'm on six milligrams at the minute. I'll probably take it down to the next level before stopping. [P8, M] M - I'm not putting any [smoking] toxins in my body, which helps. But it [the e-cigarette] is something that in the back of my mind, yeah, I want to get rid of in the long run. [P5, M]
Physical capability	Harshness of puffing	6	B	B - Sometimes there's been a burning in in my mouth at the back of my throat, and I think maybe I've taken too much or there's too much oil in it. [P5, M]

				B - I was one something like 12mg strength, and if I took a too big a mouthful of that it would make me cough like hell. I did get down to six, and that wasn’t too bad, but then six still made me cough like anything trying to get it down. [P2, M] B - Sometimes when you puff on it it's a bit too much and it makes me cough. [P4, W]
Social opportunity	Family support to quit smoking	6	E	My daughter, she don’t mind me on the e-cigarette. She says I’m much better without smoke. I’m better off with the e-cigarette than I am with a packet of cigarettes. [P2, M] My husband has been asking me to give up smoking for years and years and years. But unless you really wanna do it yourself, all the moaning in the world is not gonna make you give up. He would bend over backwards to let us go [to the SSS] [P4, F] Yes, a couple of times I was like, oh, I need a fag, because my little one had really wound me up. And I'm like, give me a fag, and he's like, ‘no’, he says, ‘you don’t need it’, basically, ‘don't ruin it now’, and then a couple of minutes pass and I'm all right. [P8, F]
Physical opportunity	Cost saving	8	E	Yeah they’re cheap enough. And if you’re packing up smoking you’ve got to think to yourself that’s £10 a packet, and an EC you can buy one for £15 and get two or three oils for £15 as well. So, you’re saving ain’t you whatever you do if you go out and buy them yourself. [P1, M]

				We're putting the money away that we I used to buy cigarettes with. You know we're up to 180 pounds in two weeks. So financially. The cigarettes that we used to buy were twelve pound a packet. So, you keep looking up my little box with my money and thinking what I could buy with that. Yeah what you can do with that money. [P3, F] I'd probably save about £25 a week. that’s £100 a month, that’s a lot of money really. [P7, M]
	Opportunities to vape	6	E	Yeah, I mean really and truthfully EC smoking is just the same as smoking. You just whip it out your pocket when you want one, go in a designated area or whatever same as you would if you were smoking, and away you go. [P1, M] I can use the e-cigarette indoors. Because it’s not actually smoking is it? It’s just a vapour in a way. [P2, M] Yes, yeah. I mean... I don’t, I’ve never smoked in the car... I’ll have a couple of puffs of that. Tony’s not gonna know that I’ve had a couple of puffs. Yeah even indoors, before he comes home from work, I’ll have a little puff rather than going out in the garden if it’s cold and raining. It’s just so easy and it doesn’t smell. [P4, F]